



**UNIVERSITI KUALA LUMPUR  
BUSINESS SCHOOL**

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**FINAL EXAMINATION  
MARCH 2024 SEMESTER**

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|-----------------------|----------------------------------------------------------|
| <b>COURSE CODE</b>    | <b>: EGB10603</b>                                        |
| <b>COURSE NAME</b>    | <b>: ECONOMIC STATISTICS 2</b>                           |
| <b>PROGRAMME NAME</b> | <b>: BACHELOR OF SCIENCE (HONS) ANALYTICAL ECONOMICS</b> |
| <b>DATE</b>           | <b>: 10 JULY 2024</b>                                    |
| <b>TIME</b>           | <b>: 2.00 PM – 5.00 PM</b>                               |
| <b>DURATION</b>       | <b>: 3 HOURS</b>                                         |

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**INSTRUCTIONS TO CANDIDATES**

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1. Please **CAREFULLY** read the instructions given in the question paper.
2. This question paper has information printed on both sides of the paper.
3. This question paper consists of **FOUR (4)** questions.
4. Answer **ALL** questions.
5. Please write your answers on the answer booklet provided.
6. Please write your name and Student ID at every page of your answer sheet.
7. All questions must be answered in **English** (any other language is not allowed).
8. Formulas, tables and graph paper have been appended for your reference.
9. **This question paper must not be removed from the examination hall.**

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**THERE ARE FIVE (5) PAGES OF QUESTIONS, INCLUDING THIS PAGE.**

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**(Total: 100 marks)****Question 1**

- (a) A high school math teacher claims that students in her class will score higher on the math portion of the final examination than students in a colleague's math class. The mean mathematics score for 49 students in her class is 22.1 and the population standard deviation is 4.8. The mean mathematics score for 44 of the colleague's students is 19.8 and the population standard deviation is 5.4. At  $\alpha = 0.10$ , can the teacher's claim be supported?  
(7 marks)
- (b) The average size of a farm in village A is 191 acres. The average size of a farm in village B is 199 acres. Assume the data were obtained from two samples with standard deviations of 38 and 12 acres, respectively, and sample sizes of 8 and 10, respectively. Can it be concluded at  $\alpha = 0.05$  that the average size of the farms in the two counties is different? Assume the populations are normally distributed  
(7 marks)
- (c) A sample of non-English majors at a selected college was used in a study to see if the student retained more from reading a 19th-century novel or by watching it in DVD form. Each student was assigned one novel to read and a different one to watch, and then they were given a 20-point written quiz on each novel. The test results are shown below. At  $\alpha = 0.05$ , can it be concluded that the book scores are higher than the DVD scores?

Table 1

|             |    |   |   |   |   |   |   |
|-------------|----|---|---|---|---|---|---|
| <b>Book</b> | 12 | 9 | 0 | 5 | 4 | 3 | 7 |
| <b>DVD</b>  | 9  | 6 | 1 | 3 | 2 | 3 | 4 |

(11 marks)

## Question 2

- (a) A recent survey stated that male college students smoke less than female college students. In a survey of 1245 male students, 361 said they smoke at least one pack of cigarettes a day. In a survey of 1065 female students, 341 said they smoke at least one pack a day. At  $\alpha = 0.01$ , can you support the claim that the proportion of male college students who smoke at least one pack of cigarettes a day is lower than the proportion of female college students who smoke at least one pack a day.

(6 marks)

- (b) A children's raincoat manufacturer wants to know whether customers prefer any specific color over other color in children's raincoats. He selects a random sample of 50 raincoats sold and notes the color. The data are shown here. At  $\alpha = 0.10$ , is there a color preference for raincoats?

Table 2

| Color       | Yellow | Red | Green | Blue |
|-------------|--------|-----|-------|------|
| No. of Sold | 17     | 13  | 8     | 12   |

(6 marks)

- (c) The following contingency table shows a random sample of 321 fatally injured passenger vehicle drivers by age and gender. The expected frequencies are displayed in parentheses. At  $\alpha = 0.05$ , can you conclude that the drivers' ages are related to gender in such accidents.

Table 3

| Gender/<br>Age | 16 - 20 | 21 - 30 | 31 - 40 | 41 - 50 | 51 - 60 | 61 and<br>older | Total |
|----------------|---------|---------|---------|---------|---------|-----------------|-------|
| Male           | 32      | 51      | 52      | 43      | 28      | 10              | 216   |
| Female         | 13      | 22      | 33      | 21      | 10      | 6               | 105   |
| Total          | 45      | 73      | 85      | 64      | 38      | 16              | 321   |

(13 marks)

## Question 3

- (a) A medical researcher wants to determine whether there is a difference in the mean length of time it takes three types of pain relievers to provide relief from headache pain. Several headache sufferers are randomly selected and given one of the three medications. Each headache sufferer records the time (in minutes) it takes the medication to begin working. The results are shown on the next slide. At  $\alpha = 0.01$ , can you conclude that the mean times are different? Assume that each population of relief times is normally distributed and that the population variances are equal.

Table 4

| Medication 1     | Medication 2     | Medication 3       |
|------------------|------------------|--------------------|
| 12               | 16               | 14                 |
| 15               | 14               | 17                 |
| 17               | 21               | 20                 |
| 12               | 15               | 15                 |
|                  | 19               |                    |
| $\bar{x}_1 = 14$ | $\bar{x}_2 = 17$ | $\bar{x}_3 = 16.5$ |
| $s_1^2 = 6$      | $s_2^2 = 8.5$    | $s_3^2 = 7$        |

(13 marks)

- (b) Tests were conducted to compare three top brands of golf balls for mean distance travelled when struck by a driver. A robotic golfer was employed with a driver to hit a random sample of 5 golf balls of each brand in a random sequence. Distance travelled, in yards, for each hit is shown in the table below.

Table 5

| Brand A              | Brand B              | Brand C              |
|----------------------|----------------------|----------------------|
| 251.2                | 263.2                | 269.7                |
| 245.1                | 262.9                | 263.2                |
| 248.0                | 265.0                | 277.5                |
| 251.1                | 254.5                | 270.5                |
| 260.5                | 264.3                | 267.4                |
| $\bar{x}_1 = 251.18$ | $\bar{x}_2 = 261.98$ | $\bar{x}_3 = 269.66$ |
| $s_1^2 = 33.487$     | $s_2^2 = 261.98$     | $s_3^2 = 27.253$     |

At  $\alpha = 0.05$ , can you conclude that the mean distance travelled are different? Assume that each population is normally distributed and that the population variances are equal.

(12 marks)

**Question 4**

For a sample of 8 employees, a personal director has collected the following data on ownership of companies stock versus years with the company.

|    | Years | Shares |
|----|-------|--------|
| 1. | 6     | 300    |
| 2. | 12    | 408    |
| 3. | 14    | 560    |
| 4. | 6     | 252    |
| 5. | 9     | 288    |
| 6. | 13    | 650    |
| 7. | 15    | 630    |
| 8. | 9     | 522    |

- (a) Plot a complete linear regression diagram with years with the firm as independent variable. State the X and Y axis and sketch the straight line to represent the regression model.  
(6 marks)
- (b) Explain the relationship between the two variables in the diagram developed in part (a)  
(2 marks)
- (c) Use the least squares method to compute the estimated regression equation.  
(12 marks)
- (d) Describe the interpretation for the slope of the estimated regression equation.  
(2 marks)
- (e) For an example who has been with the firm 10 years, calculate the number of shares of stock owned?  
(3 marks)

**END OF EXAMINATION PAPER**

## FORMULAS AND STATISTICAL TABLE

### CONFIDENT INTERVAL

$$\bar{X} - Z_{\alpha/2} \left( \frac{\sigma}{\sqrt{n}} \right) < \mu < \bar{X} + Z_{\alpha/2} \left( \frac{\sigma}{\sqrt{n}} \right)$$

$$n = \left( \frac{Z_{\alpha/2} \cdot \sigma}{E} \right)^2$$

$$\bar{X} - t_{\alpha/2} \left( \frac{s}{\sqrt{n}} \right) < \mu < \bar{X} + t_{\alpha/2} \left( \frac{s}{\sqrt{n}} \right)$$

$$\hat{p} = \frac{X}{n}, \quad \hat{q} = 1 - \hat{p}$$

$$\hat{p} - Z_{\alpha/2} \sqrt{\frac{\hat{p}\hat{q}}{n}} < \mu < \hat{p} + Z_{\alpha/2} \sqrt{\frac{\hat{p}\hat{q}}{n}}$$

$$n = \hat{p}\hat{q} \left( \frac{Z_{\alpha/2}}{E} \right)^2$$

$$\sqrt{\frac{(n-1)s^2}{\chi_{right}^2}} < \sigma < \sqrt{\frac{(n-1)s^2}{\chi_{left}^2}}, \quad d.f = n - 1$$

### HYPOTHESIS TESTING AND DISTRIBUTION

$$t = \frac{\bar{X} - \mu}{\frac{s}{\sqrt{n}}}$$

$$t = \frac{\bar{X}_d - \mu_d}{\frac{s_d}{\sqrt{n}}}$$

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

$$t = \frac{\bar{X}_1 - \bar{X}_2}{s_p \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}, \quad z = \frac{\hat{p} - p}{\sqrt{\frac{pq}{n}}}$$

#### KHI-SQUARE TEST

$$\chi^2 = \sum \frac{(O - E)^2}{E}$$

$$\chi^2 = \frac{(n-1)s^2}{\sigma^2}$$

#### HYPOTHESIS TEST TWO POPULATION

$$z = \frac{(\bar{X}_1 - \bar{X}_2) - (\mu_1 - \mu_2)}{\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}}$$

$$(\bar{X}_1 - \bar{X}_2) - Z_{\alpha/2} \sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}} < \mu_1 - \mu_2 < (\bar{X}_1 - \bar{X}_2) + Z_{\alpha/2} \sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}$$

$$F = \frac{s_1^2}{s_2^2}$$

$$t = \frac{(\bar{X}_1 - \bar{X}_2) - (\mu_1 - \mu_2)}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

$$t = \frac{(\bar{X}_1 - \bar{X}_2) - (\mu_1 - \mu_2)}{\sqrt{\frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2}{n_1 + n_2 - 2}} \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}$$

$$z = \frac{(\hat{p}_1 - \hat{p}_2) - (p_1 - p_2)}{\sqrt{\bar{p}\bar{q}\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}} \text{ with}$$

$$\hat{p}_1 = \frac{X_1}{n_1}, \hat{p}_2 = \frac{X_2}{n_2} \text{ and } \bar{p} = \frac{X_1 + X_2}{n_1 + n_2}$$

#### VARIANCE ANALYSIS ONE WAY

$$S^2_B = \frac{\sum n_i (\bar{x}_i - \bar{x}_{GM})^2}{k - 1}$$

$$\bar{x}_{GM} = \frac{\sum X}{N}$$

$$S^2_w = \frac{\sum (n_i - 1)s_i^2}{\sum (n_i - 1)}$$

$$MS_B = \frac{S^2_B}{k - 1}$$

$$MS_W = \frac{S^2_w}{N - k}$$

$$F = \frac{S^2_B}{S^2_W} = \frac{MS_B}{MS_W}$$

$$d.f.N = k - 1$$

$$d.f.D = N - k$$

### REGRESSION AND CORRELATION

$$r = \frac{n(\sum xy) - (\sum x)(\sum y)}{\sqrt{[n(\sum x^2) - (\sum x)^2][n(\sum y^2) - (\sum y)^2]}}$$

$$t = r \sqrt{\frac{n-2}{1-r^2}}$$

$$a = \frac{(\sum y)(\sum x^2) - (\sum x)(\sum xy)}{n(\sum x^2) - (\sum x)^2}$$

$$b = \frac{n(\sum xy) - (\sum x)(\sum y)}{n(\sum x^2) - (\sum x)^2}$$

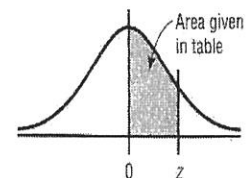


**Table E** The Standard Normal Distribution

| $z$ | .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 |

Note: Use 0.4999 for  $z$  values above 3.09.

Source: Frederick Mosteller and Robert E. K. Rourke, *Sturdy Statistics*, Table A-1 (Reading, Mass.: Addison-Wesley, 1973). Reprinted with permission of the copyright owners.



**Table F** The *t* Distribution

| d.f.         | Confidence intervals | 50%   | 80%                | 90%                | 95%    | 98%                | 99%                |
|--------------|----------------------|-------|--------------------|--------------------|--------|--------------------|--------------------|
|              | One tail, $\alpha$   | 0.25  | 0.10               | 0.05               | 0.025  | 0.01               | 0.005              |
|              | Two tails, $\alpha$  | 0.50  | 0.20               | 0.10               | 0.05   | 0.02               | 0.01               |
| 1            |                      | 1.000 | 3.078              | 6.314              | 12.706 | 31.821             | 63.657             |
| 2            |                      | .816  | 1.886              | 2.920              | 4.303  | 6.965              | 9.925              |
| 3            |                      | .765  | 1.638              | 2.353              | 3.182  | 4.541              | 5.841              |
| 4            |                      | .741  | 1.533              | 2.132              | 2.776  | 3.747              | 4.604              |
| 5            |                      | .727  | 1.476              | 2.015              | 2.571  | 3.365              | 4.032              |
| 6            |                      | .718  | 1.440              | 1.943              | 2.447  | 3.143              | 3.707              |
| 7            |                      | .711  | 1.415              | 1.895              | 2.365  | 2.998              | 3.499              |
| 8            |                      | .706  | 1.397              | 1.860              | 2.306  | 2.896              | 3.355              |
| 9            |                      | .703  | 1.383              | 1.833              | 2.262  | 2.821              | 3.250              |
| 10           |                      | .700  | 1.372              | 1.812              | 2.228  | 2.764              | 3.169              |
| 11           |                      | .697  | 1.363              | 1.796              | 2.201  | 2.718              | 3.106              |
| 12           |                      | .695  | 1.356              | 1.782              | 2.179  | 2.681              | 3.055              |
| 13           |                      | .694  | 1.350              | 1.771              | 2.160  | 2.650              | 3.012              |
| 14           |                      | .692  | 1.345              | 1.761              | 2.145  | 2.624              | 2.977              |
| 15           |                      | .691  | 1.341              | 1.753              | 2.131  | 2.602              | 2.947              |
| 16           |                      | .690  | 1.337              | 1.746              | 2.120  | 2.583              | 2.921              |
| 17           |                      | .689  | 1.333              | 1.740              | 2.110  | 2.567              | 2.898              |
| 18           |                      | .688  | 1.330              | 1.734              | 2.101  | 2.552              | 2.878              |
| 19           |                      | .688  | 1.328              | 1.729              | 2.093  | 2.539              | 2.861              |
| 20           |                      | .687  | 1.325              | 1.725              | 2.086  | 2.528              | 2.845              |
| 21           |                      | .686  | 1.323              | 1.721              | 2.080  | 2.518              | 2.831              |
| 22           |                      | .686  | 1.321              | 1.717              | 2.074  | 2.508              | 2.819              |
| 23           |                      | .685  | 1.319              | 1.714              | 2.069  | 2.500              | 2.807              |
| 24           |                      | .685  | 1.318              | 1.711              | 2.064  | 2.492              | 2.797              |
| 25           |                      | .684  | 1.316              | 1.708              | 2.060  | 2.485              | 2.787              |
| 26           |                      | .684  | 1.315              | 1.706              | 2.056  | 2.479              | 2.779              |
| 27           |                      | .684  | 1.314              | 1.703              | 2.052  | 2.473              | 2.771              |
| 28           |                      | .683  | 1.313              | 1.701              | 2.048  | 2.467              | 2.763              |
| (z) $\infty$ |                      | .674  | 1.282 <sup>a</sup> | 1.645 <sup>b</sup> | 1.960  | 2.326 <sup>c</sup> | 2.576 <sup>d</sup> |

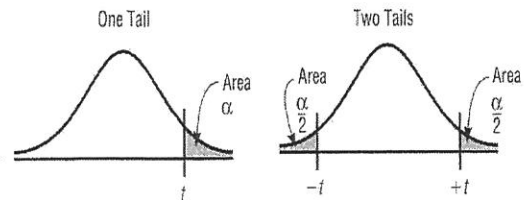
<sup>a</sup>This value has been rounded to 1.28 in the textbook.

<sup>b</sup>This value has been rounded to 1.65 in the textbook.

<sup>c</sup>This value has been rounded to 2.33 in the textbook.

<sup>d</sup>This value has been rounded to 2.58 in the textbook.

Source: Adapted from W. H. Beyer, *Handbook of Tables for Probability and Statistics*, 2nd ed., CRC Press, Boca Raton, Fla., 1986. Reprinted with permission.



**Table G** The Chi-Square Distribution

| Degrees of freedom | $\alpha$ |        |        |        |        |         |         |         |         |         |
|--------------------|----------|--------|--------|--------|--------|---------|---------|---------|---------|---------|
|                    | 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                 | 9.262    | 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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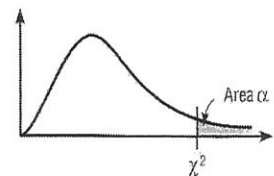




Table H The F Distribution

| d.f.D.:<br>Degrees of<br>freedom,<br>denominator |        | $\alpha = 0.005$<br>d.f.N.: Degrees of freedom, numerator |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |          |
|--------------------------------------------------|--------|-----------------------------------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|----------|
|                                                  |        | 1                                                         | 2      | 3      | 4      | 5      | 6      | 7      | 8      | 9      | 10     | 12     | 15     | 20     | 24     | 30     | 40     | 60     | 120    | $\infty$ |
| 1                                                | 16,211 | 20,000                                                    | 21,615 | 22,500 | 23,056 | 23,437 | 23,715 | 23,925 | 24,091 | 24,224 | 24,326 | 24,400 | 24,630 | 24,836 | 24,940 | 25,044 | 25,148 | 25,253 | 25,359 | 25,465   |
| 2                                                | 198.5  | 199.0                                                     | 199.2  | 199.2  | 199.3  | 199.3  | 199.4  | 199.4  | 199.4  | 199.4  | 199.4  | 199.4  | 199.4  | 199.4  | 199.5  | 199.5  | 199.5  | 199.5  | 199.5  | 199.5    |
| 3                                                | 55.55  | 49.80                                                     | 47.47  | 46.19  | 45.39  | 44.84  | 44.43  | 44.13  | 43.88  | 43.69  | 43.53  | 43.39  | 43.08  | 42.78  | 42.62  | 42.47  | 42.31  | 42.15  | 41.99  | 41.83    |
| 4                                                | 31.33  | 26.28                                                     | 24.26  | 23.15  | 22.46  | 21.97  | 21.62  | 21.35  | 21.14  | 20.97  | 20.70  | 20.70  | 20.44  | 20.17  | 20.03  | 19.89  | 19.75  | 19.61  | 19.47  | 19.32    |
| 5                                                | 22.78  | 18.31                                                     | 16.53  | 15.56  | 14.94  | 14.51  | 14.20  | 13.96  | 13.77  | 13.62  | 13.38  | 13.38  | 13.15  | 12.90  | 12.78  | 12.66  | 12.53  | 12.40  | 12.27  | 12.14    |
| 6                                                | 18.63  | 14.54                                                     | 12.92  | 12.03  | 11.46  | 11.07  | 10.79  | 10.57  | 10.39  | 10.25  | 10.03  | 10.03  | 9.81   | 9.59   | 9.47   | 9.36   | 9.24   | 9.12   | 9.00   | 8.88     |
| 7                                                | 16.24  | 12.40                                                     | 10.88  | 10.05  | 9.52   | 9.16   | 8.89   | 8.68   | 8.51   | 8.38   | 8.18   | 8.18   | 7.97   | 7.75   | 7.65   | 7.53   | 7.42   | 7.31   | 7.19   | 7.08     |
| 8                                                | 14.69  | 11.04                                                     | 9.60   | 8.81   | 8.30   | 7.95   | 7.69   | 7.50   | 7.34   | 7.21   | 7.01   | 7.01   | 6.81   | 6.61   | 6.50   | 6.40   | 6.29   | 6.18   | 6.06   | 5.95     |
| 9                                                | 13.61  | 10.11                                                     | 8.72   | 7.96   | 7.47   | 7.13   | 6.88   | 6.69   | 6.54   | 6.42   | 6.23   | 6.23   | 6.03   | 5.83   | 5.73   | 5.62   | 5.52   | 5.41   | 5.30   | 5.19     |
| 10                                               | 12.83  | 9.43                                                      | 8.08   | 7.34   | 6.87   | 6.54   | 6.30   | 6.12   | 5.97   | 5.85   | 5.66   | 5.66   | 5.47   | 5.27   | 5.17   | 5.07   | 4.97   | 4.86   | 4.75   | 4.64     |
| 11                                               | 12.23  | 8.91                                                      | 7.60   | 6.88   | 6.42   | 6.10   | 5.86   | 5.68   | 5.54   | 5.42   | 5.24   | 5.24   | 5.05   | 4.86   | 4.76   | 4.65   | 4.55   | 4.44   | 4.34   | 4.23     |
| 12                                               | 11.75  | 8.51                                                      | 7.23   | 6.52   | 6.07   | 5.76   | 5.52   | 5.35   | 5.20   | 5.09   | 4.91   | 4.91   | 4.72   | 4.53   | 4.43   | 4.33   | 4.23   | 4.12   | 4.01   | 3.90     |
| 13                                               | 11.37  | 8.19                                                      | 6.93   | 6.23   | 5.79   | 5.48   | 5.25   | 5.08   | 4.94   | 4.82   | 4.64   | 4.64   | 4.45   | 4.27   | 4.17   | 4.07   | 3.97   | 3.87   | 3.76   | 3.65     |
| 14                                               | 11.06  | 7.92                                                      | 6.68   | 6.00   | 5.56   | 5.26   | 5.03   | 4.86   | 4.72   | 4.60   | 4.43   | 4.43   | 4.25   | 4.06   | 3.96   | 3.86   | 3.76   | 3.66   | 3.55   | 3.44     |
| 15                                               | 10.80  | 7.70                                                      | 6.48   | 5.80   | 5.37   | 5.07   | 4.85   | 4.67   | 4.54   | 4.42   | 4.25   | 4.25   | 4.07   | 3.88   | 3.79   | 3.69   | 3.58   | 3.48   | 3.37   | 3.26     |
| 16                                               | 10.58  | 7.51                                                      | 6.30   | 5.64   | 5.21   | 4.91   | 4.69   | 4.52   | 4.38   | 4.27   | 4.10   | 4.10   | 3.92   | 3.73   | 3.64   | 3.54   | 3.44   | 3.33   | 3.22   | 3.11     |
| 17                                               | 10.38  | 7.35                                                      | 6.16   | 5.50   | 5.07   | 4.78   | 4.56   | 4.39   | 4.25   | 4.14   | 3.97   | 3.97   | 3.79   | 3.61   | 3.51   | 3.41   | 3.31   | 3.21   | 3.10   | 2.98     |
| 18                                               | 10.22  | 7.21                                                      | 6.03   | 5.37   | 4.96   | 4.66   | 4.44   | 4.28   | 4.14   | 4.03   | 3.86   | 3.86   | 3.68   | 3.50   | 3.40   | 3.30   | 3.20   | 3.10   | 2.99   | 2.87     |
| 19                                               | 10.07  | 7.09                                                      | 5.92   | 5.27   | 4.85   | 4.56   | 4.34   | 4.18   | 4.04   | 3.93   | 3.76   | 3.76   | 3.59   | 3.40   | 3.31   | 3.21   | 3.11   | 3.00   | 2.89   | 2.78     |
| 20                                               | 9.94   | 6.99                                                      | 5.82   | 5.17   | 4.76   | 4.47   | 4.26   | 4.09   | 3.96   | 3.85   | 3.68   | 3.68   | 3.50   | 3.32   | 3.22   | 3.12   | 3.02   | 2.92   | 2.81   | 2.69     |
| 21                                               | 9.83   | 6.89                                                      | 5.73   | 5.09   | 4.68   | 4.39   | 4.18   | 4.01   | 3.88   | 3.77   | 3.60   | 3.60   | 3.43   | 3.24   | 3.15   | 3.05   | 2.95   | 2.84   | 2.73   | 2.61     |
| 22                                               | 9.73   | 6.81                                                      | 5.65   | 5.02   | 4.61   | 4.32   | 4.11   | 3.94   | 3.81   | 3.70   | 3.54   | 3.54   | 3.36   | 3.18   | 3.08   | 2.98   | 2.88   | 2.77   | 2.66   | 2.55     |
| 23                                               | 9.63   | 6.73                                                      | 5.58   | 4.95   | 4.54   | 4.26   | 4.05   | 3.88   | 3.75   | 3.64   | 3.47   | 3.47   | 3.30   | 3.12   | 3.02   | 2.92   | 2.82   | 2.71   | 2.60   | 2.48     |
| 24                                               | 9.55   | 6.66                                                      | 5.52   | 4.89   | 4.49   | 4.20   | 3.99   | 3.83   | 3.69   | 3.59   | 3.42   | 3.42   | 3.25   | 3.06   | 2.97   | 2.87   | 2.77   | 2.66   | 2.55   | 2.43     |
| 25                                               | 9.48   | 6.60                                                      | 5.46   | 4.84   | 4.43   | 4.15   | 3.94   | 3.78   | 3.64   | 3.54   | 3.37   | 3.37   | 3.20   | 3.01   | 2.92   | 2.82   | 2.72   | 2.61   | 2.50   | 2.38     |
| 26                                               | 9.41   | 6.54                                                      | 5.41   | 4.79   | 4.38   | 4.10   | 3.89   | 3.73   | 3.60   | 3.49   | 3.33   | 3.33   | 3.15   | 2.97   | 2.87   | 2.77   | 2.67   | 2.56   | 2.45   | 2.33     |
| 27                                               | 9.34   | 6.49                                                      | 5.36   | 4.74   | 4.34   | 4.06   | 3.85   | 3.69   | 3.56   | 3.45   | 3.28   | 3.28   | 3.11   | 2.93   | 2.83   | 2.73   | 2.63   | 2.52   | 2.41   | 2.29     |
| 28                                               | 9.28   | 6.44                                                      | 5.32   | 4.70   | 4.30   | 4.02   | 3.81   | 3.65   | 3.52   | 3.41   | 3.25   | 3.25   | 3.07   | 2.89   | 2.79   | 2.69   | 2.59   | 2.48   | 2.37   | 2.25     |
| 29                                               | 9.23   | 6.40                                                      | 5.28   | 4.66   | 4.26   | 3.98   | 3.77   | 3.61   | 3.48   | 3.38   | 3.22   | 3.22   | 3.04   | 2.86   | 2.76   | 2.66   | 2.56   | 2.45   | 2.33   | 2.24     |
| 30                                               | 9.18   | 6.35                                                      | 5.24   | 4.62   | 4.23   | 3.95   | 3.74   | 3.58   | 3.45   | 3.34   | 3.18   | 3.18   | 3.01   | 2.82   | 2.73   | 2.63   | 2.52   | 2.42   | 2.30   | 2.18     |
| 40                                               | 8.83   | 6.07                                                      | 4.98   | 4.37   | 3.99   | 3.71   | 3.51   | 3.35   | 3.22   | 3.12   | 2.95   | 2.95   | 2.78   | 2.60   | 2.50   | 2.40   | 2.30   | 2.18   | 2.06   | 1.93     |
| 60                                               | 8.49   | 5.79                                                      | 4.73   | 4.14   | 3.76   | 3.49   | 3.29   | 3.13   | 3.01   | 2.90   | 2.74   | 2.74   | 2.57   | 2.39   | 2.29   | 2.19   | 2.08   | 1.96   | 1.83   | 1.69     |
| 120                                              | 8.18   | 5.54                                                      | 4.50   | 3.92   | 3.55   | 3.28   | 3.09   | 2.93   | 2.81   | 2.71   | 2.54   | 2.54   | 2.37   | 2.19   | 2.09   | 1.98   | 1.87   | 1.75   | 1.61   | 1.43     |
| $\infty$                                         | 7.88   | 5.30                                                      | 4.28   | 3.72   | 3.35   | 3.09   | 2.90   | 2.74   | 2.62   | 2.52   | 2.36   | 2.36   | 2.19   | 2.00   | 1.90   | 1.79   | 1.67   | 1.53   | 1.36   | 1.00     |

Table H (continued)

| d.f.D.:<br>Degrees of<br>freedom,<br>denominator | $\alpha = 0.01$                       |        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |          |  |
|--------------------------------------------------|---------------------------------------|--------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|----------|--|
|                                                  | d.f.N.: Degrees of freedom, numerator |        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |          |  |
|                                                  | 1                                     | 2      | 3     | 4     | 5     | 6     | 7     | 8     | 9     | 10    | 12    | 15    | 20    | 24    | 30    | 40    | 60    | 120   | $\infty$ |  |
| 1                                                | 4052                                  | 4999.5 | 5403  | 5625  | 5764  | 5859  | 5928  | 5982  | 6022  | 6056  | 6106  | 6157  | 6209  | 6235  | 6261  | 6287  | 6313  | 6339  | 6366     |  |
| 2                                                | 98.50                                 | 99.00  | 99.17 | 99.25 | 99.30 | 99.33 | 99.36 | 99.37 | 99.39 | 99.40 | 99.42 | 99.43 | 99.45 | 99.46 | 99.47 | 99.47 | 99.48 | 99.49 | 99.50    |  |
| 3                                                | 34.12                                 | 30.82  | 29.46 | 28.71 | 28.24 | 27.91 | 27.67 | 27.49 | 27.35 | 27.23 | 27.05 | 26.87 | 26.69 | 26.60 | 26.50 | 26.41 | 26.32 | 26.22 | 26.13    |  |
| 4                                                | 21.20                                 | 18.00  | 16.69 | 15.98 | 15.52 | 15.21 | 14.98 | 14.80 | 14.66 | 14.55 | 14.37 | 14.20 | 14.02 | 13.93 | 13.84 | 13.75 | 13.65 | 13.56 | 13.46    |  |
| 5                                                | 16.26                                 | 13.27  | 12.06 | 11.39 | 10.97 | 10.67 | 10.46 | 10.29 | 10.16 | 10.05 | 9.89  | 9.72  | 9.55  | 9.47  | 9.38  | 9.29  | 9.20  | 9.11  | 9.02     |  |
| 6                                                | 13.75                                 | 10.92  | 9.78  | 9.15  | 8.75  | 8.47  | 8.26  | 8.10  | 7.98  | 7.87  | 7.72  | 7.56  | 7.40  | 7.31  | 7.23  | 7.14  | 7.06  | 6.97  | 6.88     |  |
| 7                                                | 12.25                                 | 9.55   | 8.45  | 7.85  | 7.46  | 7.19  | 6.99  | 6.84  | 6.72  | 6.62  | 6.47  | 6.31  | 6.16  | 6.07  | 5.99  | 5.91  | 5.82  | 5.74  | 5.65     |  |
| 8                                                | 11.26                                 | 8.65   | 7.59  | 7.01  | 6.63  | 6.37  | 6.18  | 6.03  | 5.91  | 5.81  | 5.67  | 5.52  | 5.36  | 5.28  | 5.20  | 5.12  | 5.03  | 4.95  | 4.86     |  |
| 9                                                | 10.56                                 | 8.02   | 6.99  | 6.42  | 6.06  | 5.80  | 5.61  | 5.47  | 5.35  | 5.26  | 5.11  | 4.96  | 4.81  | 4.73  | 4.65  | 4.57  | 4.48  | 4.40  | 4.31     |  |
| 10                                               | 10.04                                 | 7.56   | 6.55  | 5.99  | 5.64  | 5.39  | 5.20  | 5.06  | 4.94  | 4.85  | 4.71  | 4.56  | 4.41  | 4.33  | 4.25  | 4.17  | 4.08  | 4.00  | 3.91     |  |
| 11                                               | 9.65                                  | 7.21   | 6.22  | 5.67  | 5.32  | 5.07  | 4.89  | 4.74  | 4.63  | 4.54  | 4.40  | 4.25  | 4.10  | 4.02  | 3.94  | 3.86  | 3.78  | 3.69  | 3.60     |  |
| 12                                               | 9.33                                  | 6.93   | 5.95  | 5.41  | 5.06  | 4.82  | 4.64  | 4.50  | 4.39  | 4.30  | 4.16  | 4.01  | 3.86  | 3.78  | 3.70  | 3.62  | 3.54  | 3.45  | 3.36     |  |
| 13                                               | 9.07                                  | 6.70   | 5.74  | 5.21  | 4.86  | 4.62  | 4.44  | 4.30  | 4.19  | 4.10  | 3.96  | 3.82  | 3.66  | 3.59  | 3.51  | 3.43  | 3.34  | 3.25  | 3.17     |  |
| 14                                               | 8.86                                  | 6.51   | 5.56  | 5.04  | 4.69  | 4.46  | 4.28  | 4.14  | 4.03  | 3.94  | 3.80  | 3.66  | 3.51  | 3.43  | 3.35  | 3.27  | 3.18  | 3.09  | 3.00     |  |
| 15                                               | 8.68                                  | 6.36   | 5.42  | 4.89  | 4.56  | 4.32  | 4.14  | 4.00  | 3.89  | 3.80  | 3.67  | 3.52  | 3.37  | 3.29  | 3.21  | 3.13  | 3.05  | 2.96  | 2.87     |  |
| 16                                               | 8.53                                  | 6.23   | 5.29  | 4.77  | 4.44  | 4.20  | 4.03  | 3.89  | 3.78  | 3.69  | 3.55  | 3.41  | 3.26  | 3.18  | 3.10  | 3.02  | 2.93  | 2.84  | 2.75     |  |
| 17                                               | 8.40                                  | 6.11   | 5.18  | 4.67  | 4.34  | 4.10  | 3.93  | 3.79  | 3.68  | 3.59  | 3.46  | 3.31  | 3.16  | 3.08  | 3.00  | 2.92  | 2.83  | 2.75  | 2.65     |  |
| 18                                               | 8.29                                  | 6.01   | 5.09  | 4.58  | 4.25  | 4.01  | 3.84  | 3.71  | 3.60  | 3.51  | 3.37  | 3.23  | 3.08  | 3.00  | 2.92  | 2.84  | 2.75  | 2.66  | 2.57     |  |
| 19                                               | 8.18                                  | 5.93   | 5.01  | 4.50  | 4.17  | 3.94  | 3.77  | 3.63  | 3.52  | 3.43  | 3.30  | 3.15  | 3.00  | 2.92  | 2.84  | 2.76  | 2.67  | 2.58  | 2.49     |  |
| 20                                               | 8.10                                  | 5.85   | 4.94  | 4.43  | 4.10  | 3.87  | 3.70  | 3.56  | 3.46  | 3.37  | 3.23  | 3.09  | 2.94  | 2.86  | 2.78  | 2.69  | 2.61  | 2.52  | 2.42     |  |
| 21                                               | 8.02                                  | 5.78   | 4.87  | 4.37  | 4.04  | 3.81  | 3.64  | 3.51  | 3.40  | 3.31  | 3.17  | 3.03  | 2.88  | 2.80  | 2.72  | 2.64  | 2.55  | 2.46  | 2.36     |  |
| 22                                               | 7.95                                  | 5.72   | 4.82  | 4.31  | 3.99  | 3.76  | 3.59  | 3.45  | 3.35  | 3.26  | 3.12  | 2.98  | 2.83  | 2.75  | 2.67  | 2.58  | 2.50  | 2.40  | 2.31     |  |
| 23                                               | 7.88                                  | 5.66   | 4.76  | 4.26  | 3.94  | 3.71  | 3.54  | 3.41  | 3.30  | 3.21  | 3.07  | 2.93  | 2.78  | 2.70  | 2.62  | 2.54  | 2.45  | 2.35  | 2.26     |  |
| 24                                               | 7.82                                  | 5.61   | 4.72  | 4.22  | 3.90  | 3.67  | 3.50  | 3.36  | 3.26  | 3.17  | 3.03  | 2.89  | 2.74  | 2.66  | 2.58  | 2.49  | 2.40  | 2.31  | 2.21     |  |
| 25                                               | 7.77                                  | 5.57   | 4.68  | 4.18  | 3.85  | 3.63  | 3.46  | 3.32  | 3.22  | 3.13  | 2.99  | 2.85  | 2.70  | 2.62  | 2.54  | 2.45  | 2.36  | 2.27  | 2.17     |  |
| 26                                               | 7.72                                  | 5.53   | 4.64  | 4.14  | 3.82  | 3.59  | 3.42  | 3.29  | 3.18  | 3.09  | 2.96  | 2.81  | 2.66  | 2.58  | 2.50  | 2.42  | 2.33  | 2.23  | 2.13     |  |
| 27                                               | 7.68                                  | 5.49   | 4.60  | 4.11  | 3.78  | 3.56  | 3.39  | 3.26  | 3.15  | 3.06  | 2.93  | 2.78  | 2.63  | 2.55  | 2.47  | 2.38  | 2.29  | 2.20  | 2.10     |  |
| 28                                               | 7.64                                  | 5.45   | 4.57  | 4.07  | 3.75  | 3.53  | 3.36  | 3.23  | 3.12  | 3.03  | 2.90  | 2.75  | 2.60  | 2.52  | 2.44  | 2.35  | 2.26  | 2.17  | 2.06     |  |
| 29                                               | 7.60                                  | 5.42   | 4.54  | 4.04  | 3.73  | 3.50  | 3.33  | 3.20  | 3.09  | 3.00  | 2.87  | 2.73  | 2.57  | 2.49  | 2.41  | 2.33  | 2.23  | 2.14  | 2.03     |  |
| 30                                               | 7.56                                  | 5.39   | 4.51  | 4.02  | 3.70  | 3.47  | 3.30  | 3.17  | 3.07  | 2.98  | 2.84  | 2.70  | 2.55  | 2.47  | 2.39  | 2.30  | 2.21  | 2.11  | 2.01     |  |
| 40                                               | 7.31                                  | 5.18   | 4.31  | 3.83  | 3.51  | 3.29  | 3.12  | 2.99  | 2.89  | 2.80  | 2.66  | 2.52  | 2.37  | 2.29  | 2.20  | 2.11  | 2.02  | 1.92  | 1.80     |  |
| 60                                               | 7.08                                  | 4.98   | 4.13  | 3.65  | 3.34  | 3.12  | 2.95  | 2.82  | 2.72  | 2.63  | 2.50  | 2.35  | 2.20  | 2.12  | 2.03  | 1.94  | 1.84  | 1.73  | 1.60     |  |
| 120                                              | 6.85                                  | 4.79   | 3.95  | 3.48  | 3.17  | 2.96  | 2.79  | 2.66  | 2.56  | 2.47  | 2.34  | 2.19  | 2.03  | 1.95  | 1.86  | 1.76  | 1.66  | 1.53  | 1.38     |  |
| $\infty$                                         | 6.63                                  | 4.61   | 3.78  | 3.32  | 3.02  | 2.80  | 2.64  | 2.51  | 2.41  | 2.32  | 2.18  | 2.04  | 1.88  | 1.79  | 1.70  | 1.59  | 1.47  | 1.32  | 1.00     |  |



Table H (continued)

| d.f.D.:<br>Degrees of<br>freedom,<br>denominator |       | $\alpha = 0.025$<br>d.f.N.: Degrees of freedom, numerator |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |          |
|--------------------------------------------------|-------|-----------------------------------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|----------|
|                                                  |       | 1                                                         | 2     | 3     | 4     | 5     | 6     | 7     | 8     | 9     | 10    | 12    | 15    | 20    | 24    | 30    | 40    | 60    | 120   | $\infty$ |
| 1                                                | 647.8 | 799.5                                                     | 864.2 | 899.6 | 921.8 | 937.1 | 948.2 | 956.7 | 963.3 | 968.6 | 976.7 | 984.9 | 993.1 | 997.2 | 1001  | 1006  | 1010  | 1014  | 1018  | 1018     |
| 2                                                | 38.51 | 39.00                                                     | 39.17 | 39.25 | 39.30 | 39.33 | 39.36 | 39.37 | 39.39 | 39.40 | 39.41 | 39.43 | 39.45 | 39.46 | 39.46 | 39.47 | 39.48 | 39.49 | 39.50 | 39.50    |
| 3                                                | 17.44 | 16.04                                                     | 15.44 | 15.10 | 14.88 | 14.73 | 14.62 | 14.54 | 14.47 | 14.42 | 14.34 | 14.25 | 14.17 | 14.12 | 14.08 | 14.04 | 13.99 | 13.95 | 13.90 | 13.90    |
| 4                                                | 12.22 | 10.65                                                     | 9.98  | 9.60  | 9.36  | 9.20  | 9.07  | 8.98  | 8.90  | 8.84  | 8.75  | 8.66  | 8.56  | 8.51  | 8.46  | 8.41  | 8.36  | 8.31  | 8.26  | 8.26     |
| 5                                                | 10.01 | 8.43                                                      | 7.76  | 7.39  | 7.15  | 6.98  | 6.85  | 6.76  | 6.68  | 6.62  | 6.52  | 6.43  | 6.33  | 6.28  | 6.23  | 6.18  | 6.12  | 6.07  | 6.02  | 6.02     |
| 6                                                | 8.81  | 7.26                                                      | 6.60  | 6.23  | 5.99  | 5.82  | 5.70  | 5.60  | 5.52  | 5.46  | 5.37  | 5.27  | 5.17  | 5.12  | 5.07  | 5.01  | 4.96  | 4.90  | 4.85  | 4.85     |
| 7                                                | 8.07  | 6.54                                                      | 5.89  | 5.52  | 5.29  | 5.12  | 4.99  | 4.90  | 4.82  | 4.76  | 4.67  | 4.57  | 4.47  | 4.42  | 4.36  | 4.31  | 4.25  | 4.20  | 4.14  | 4.14     |
| 8                                                | 7.57  | 6.06                                                      | 5.42  | 5.05  | 4.82  | 4.65  | 4.53  | 4.43  | 4.36  | 4.30  | 4.20  | 4.10  | 4.00  | 3.95  | 3.89  | 3.84  | 3.78  | 3.73  | 3.67  | 3.67     |
| 9                                                | 7.21  | 5.71                                                      | 5.08  | 4.72  | 4.48  | 4.32  | 4.20  | 4.10  | 4.03  | 3.96  | 3.87  | 3.77  | 3.67  | 3.61  | 3.56  | 3.51  | 3.45  | 3.39  | 3.33  | 3.33     |
| 10                                               | 6.94  | 5.46                                                      | 4.83  | 4.47  | 4.24  | 4.07  | 3.95  | 3.85  | 3.78  | 3.72  | 3.62  | 3.52  | 3.42  | 3.37  | 3.31  | 3.26  | 3.20  | 3.14  | 3.08  | 3.08     |
| 11                                               | 6.72  | 5.26                                                      | 4.63  | 4.28  | 4.04  | 3.88  | 3.76  | 3.66  | 3.59  | 3.53  | 3.43  | 3.33  | 3.23  | 3.17  | 3.12  | 3.06  | 3.00  | 2.94  | 2.88  | 2.88     |
| 12                                               | 6.55  | 5.10                                                      | 4.47  | 4.12  | 3.89  | 3.73  | 3.61  | 3.51  | 3.44  | 3.37  | 3.28  | 3.18  | 3.07  | 3.02  | 2.96  | 2.91  | 2.85  | 2.79  | 2.72  | 2.72     |
| 13                                               | 6.41  | 4.97                                                      | 4.35  | 4.00  | 3.77  | 3.60  | 3.48  | 3.39  | 3.31  | 3.25  | 3.15  | 3.05  | 2.95  | 2.89  | 2.84  | 2.78  | 2.72  | 2.66  | 2.60  | 2.60     |
| 14                                               | 6.30  | 4.86                                                      | 4.24  | 3.89  | 3.66  | 3.50  | 3.38  | 3.29  | 3.21  | 3.15  | 3.05  | 2.95  | 2.84  | 2.79  | 2.73  | 2.67  | 2.61  | 2.55  | 2.49  | 2.49     |
| 15                                               | 6.20  | 4.77                                                      | 4.15  | 3.80  | 3.58  | 3.41  | 3.29  | 3.20  | 3.12  | 3.06  | 2.96  | 2.86  | 2.76  | 2.70  | 2.64  | 2.59  | 2.52  | 2.46  | 2.40  | 2.40     |
| 16                                               | 6.12  | 4.69                                                      | 4.08  | 3.73  | 3.50  | 3.34  | 3.22  | 3.12  | 3.05  | 2.99  | 2.89  | 2.79  | 2.68  | 2.63  | 2.57  | 2.51  | 2.45  | 2.38  | 2.32  | 2.32     |
| 17                                               | 6.04  | 4.62                                                      | 4.01  | 3.66  | 3.44  | 3.28  | 3.16  | 3.06  | 2.98  | 2.92  | 2.82  | 2.72  | 2.62  | 2.56  | 2.50  | 2.44  | 2.38  | 2.32  | 2.25  | 2.25     |
| 18                                               | 5.98  | 4.56                                                      | 3.95  | 3.61  | 3.38  | 3.22  | 3.10  | 3.01  | 2.93  | 2.87  | 2.77  | 2.67  | 2.56  | 2.50  | 2.44  | 2.38  | 2.32  | 2.26  | 2.19  | 2.19     |
| 19                                               | 5.92  | 4.51                                                      | 3.90  | 3.56  | 3.33  | 3.17  | 3.05  | 2.96  | 2.88  | 2.82  | 2.72  | 2.62  | 2.51  | 2.45  | 2.39  | 2.33  | 2.27  | 2.20  | 2.13  | 2.13     |
| 20                                               | 5.87  | 4.46                                                      | 3.86  | 3.51  | 3.29  | 3.13  | 3.01  | 2.91  | 2.84  | 2.77  | 2.68  | 2.57  | 2.46  | 2.41  | 2.35  | 2.29  | 2.22  | 2.16  | 2.09  | 2.09     |
| 21                                               | 5.83  | 4.42                                                      | 3.82  | 3.48  | 3.25  | 3.09  | 2.97  | 2.87  | 2.80  | 2.73  | 2.64  | 2.53  | 2.42  | 2.37  | 2.31  | 2.25  | 2.18  | 2.11  | 2.04  | 2.04     |
| 22                                               | 5.79  | 4.38                                                      | 3.78  | 3.44  | 3.22  | 3.05  | 2.93  | 2.84  | 2.76  | 2.70  | 2.60  | 2.50  | 2.39  | 2.33  | 2.27  | 2.21  | 2.14  | 2.08  | 2.00  | 2.00     |
| 23                                               | 5.75  | 4.35                                                      | 3.75  | 3.41  | 3.18  | 3.02  | 2.90  | 2.81  | 2.73  | 2.67  | 2.57  | 2.47  | 2.36  | 2.30  | 2.24  | 2.18  | 2.11  | 2.04  | 1.97  | 1.97     |
| 24                                               | 5.72  | 4.32                                                      | 3.72  | 3.38  | 3.15  | 2.99  | 2.87  | 2.78  | 2.70  | 2.64  | 2.54  | 2.44  | 2.33  | 2.27  | 2.21  | 2.15  | 2.08  | 2.01  | 1.94  | 1.94     |
| 25                                               | 5.69  | 4.29                                                      | 3.69  | 3.35  | 3.13  | 2.97  | 2.85  | 2.75  | 2.68  | 2.61  | 2.51  | 2.41  | 2.30  | 2.24  | 2.18  | 2.12  | 2.05  | 1.98  | 1.91  | 1.91     |
| 26                                               | 5.66  | 4.27                                                      | 3.67  | 3.33  | 3.10  | 2.94  | 2.82  | 2.73  | 2.65  | 2.59  | 2.49  | 2.39  | 2.28  | 2.22  | 2.16  | 2.09  | 2.03  | 1.95  | 1.88  | 1.88     |
| 27                                               | 5.63  | 4.24                                                      | 3.65  | 3.31  | 3.08  | 2.92  | 2.80  | 2.71  | 2.63  | 2.57  | 2.47  | 2.36  | 2.25  | 2.19  | 2.13  | 2.07  | 2.00  | 1.93  | 1.85  | 1.85     |
| 28                                               | 5.61  | 4.22                                                      | 3.63  | 3.29  | 3.06  | 2.90  | 2.78  | 2.69  | 2.61  | 2.55  | 2.45  | 2.34  | 2.23  | 2.17  | 2.11  | 2.05  | 1.98  | 1.91  | 1.83  | 1.83     |
| 29                                               | 5.59  | 4.20                                                      | 3.61  | 3.27  | 3.04  | 2.88  | 2.76  | 2.67  | 2.59  | 2.53  | 2.43  | 2.32  | 2.21  | 2.15  | 2.09  | 2.03  | 1.96  | 1.89  | 1.81  | 1.81     |
| 30                                               | 5.57  | 4.18                                                      | 3.59  | 3.25  | 3.03  | 2.87  | 2.75  | 2.65  | 2.57  | 2.51  | 2.41  | 2.31  | 2.20  | 2.14  | 2.07  | 2.01  | 1.94  | 1.87  | 1.79  | 1.79     |
| 40                                               | 5.42  | 4.05                                                      | 3.46  | 3.13  | 2.90  | 2.74  | 2.62  | 2.53  | 2.45  | 2.39  | 2.29  | 2.18  | 2.07  | 2.01  | 1.94  | 1.88  | 1.80  | 1.72  | 1.64  | 1.64     |
| 60                                               | 5.29  | 3.93                                                      | 3.34  | 3.01  | 2.79  | 2.63  | 2.51  | 2.41  | 2.33  | 2.27  | 2.17  | 2.06  | 1.94  | 1.88  | 1.82  | 1.74  | 1.67  | 1.58  | 1.48  | 1.48     |
| 120                                              | 5.15  | 3.80                                                      | 3.23  | 2.89  | 2.67  | 2.52  | 2.39  | 2.30  | 2.22  | 2.16  | 2.05  | 1.94  | 1.82  | 1.76  | 1.69  | 1.61  | 1.53  | 1.43  | 1.31  | 1.31     |
| $\infty$                                         | 5.02  | 3.69                                                      | 3.12  | 2.79  | 2.57  | 2.41  | 2.29  | 2.19  | 2.11  | 2.05  | 1.94  | 1.83  | 1.71  | 1.64  | 1.57  | 1.48  | 1.39  | 1.27  | 1.00  | 1.00     |

Table H (continued)

| d.f.D:<br>Degrees of<br>freedom,<br>denominator | $\alpha = 0.05$                       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |          |
|-------------------------------------------------|---------------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|----------|
|                                                 | d.f.N.: Degrees of freedom, numerator |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |          |
|                                                 | 1                                     | 2     | 3     | 4     | 5     | 6     | 7     | 8     | 9     | 10    | 12    | 15    | 20    | 24    | 30    | 40    | 60    | 120   | $\infty$ |
| 1                                               | 161.4                                 | 199.5 | 215.7 | 224.6 | 230.2 | 234.0 | 236.8 | 238.9 | 240.5 | 241.9 | 243.9 | 245.9 | 248.0 | 249.1 | 250.1 | 251.1 | 252.2 | 253.3 | 254.3    |
| 2                                               | 18.51                                 | 19.00 | 19.16 | 19.25 | 19.30 | 19.33 | 19.35 | 19.37 | 19.38 | 19.40 | 19.41 | 19.43 | 19.45 | 19.45 | 19.46 | 19.47 | 19.48 | 19.49 | 19.50    |
| 3                                               | 10.13                                 | 9.55  | 9.28  | 9.12  | 9.01  | 8.94  | 8.89  | 8.85  | 8.81  | 8.79  | 8.74  | 8.70  | 8.66  | 8.64  | 8.62  | 8.59  | 8.57  | 8.55  | 8.53     |
| 4                                               | 7.71                                  | 6.94  | 6.59  | 6.39  | 6.26  | 6.16  | 6.09  | 6.04  | 6.00  | 5.96  | 5.91  | 5.86  | 5.80  | 5.77  | 5.75  | 5.72  | 5.69  | 5.66  | 5.63     |
| 5                                               | 6.61                                  | 5.79  | 5.41  | 5.19  | 5.05  | 4.95  | 4.88  | 4.82  | 4.77  | 4.74  | 4.68  | 4.62  | 4.56  | 4.53  | 4.50  | 4.46  | 4.43  | 4.40  | 4.36     |
| 6                                               | 5.99                                  | 5.14  | 4.76  | 4.53  | 4.39  | 4.28  | 4.21  | 4.15  | 4.10  | 4.06  | 4.00  | 3.94  | 3.87  | 3.84  | 3.81  | 3.77  | 3.74  | 3.70  | 3.67     |
| 7                                               | 5.59                                  | 4.74  | 4.35  | 4.12  | 3.97  | 3.87  | 3.79  | 3.73  | 3.68  | 3.64  | 3.57  | 3.51  | 3.44  | 3.41  | 3.38  | 3.34  | 3.30  | 3.27  | 3.23     |
| 8                                               | 5.32                                  | 4.46  | 4.07  | 3.84  | 3.69  | 3.58  | 3.50  | 3.44  | 3.39  | 3.35  | 3.28  | 3.22  | 3.15  | 3.12  | 3.08  | 3.04  | 3.01  | 2.97  | 2.93     |
| 9                                               | 5.12                                  | 4.26  | 3.86  | 3.63  | 3.48  | 3.37  | 3.29  | 3.23  | 3.18  | 3.14  | 3.07  | 3.01  | 2.94  | 2.90  | 2.86  | 2.83  | 2.79  | 2.75  | 2.71     |
| 10                                              | 4.96                                  | 4.10  | 3.71  | 3.48  | 3.33  | 3.22  | 3.14  | 3.07  | 3.02  | 2.98  | 2.91  | 2.85  | 2.77  | 2.74  | 2.70  | 2.66  | 2.62  | 2.58  | 2.54     |
| 11                                              | 4.84                                  | 3.98  | 3.59  | 3.36  | 3.20  | 3.09  | 3.01  | 2.95  | 2.90  | 2.85  | 2.79  | 2.72  | 2.65  | 2.61  | 2.57  | 2.53  | 2.49  | 2.45  | 2.40     |
| 12                                              | 4.75                                  | 3.89  | 3.49  | 3.26  | 3.11  | 3.00  | 2.91  | 2.85  | 2.80  | 2.75  | 2.69  | 2.62  | 2.54  | 2.51  | 2.47  | 2.43  | 2.38  | 2.34  | 2.30     |
| 13                                              | 4.67                                  | 3.81  | 3.41  | 3.18  | 3.03  | 2.92  | 2.83  | 2.77  | 2.71  | 2.67  | 2.60  | 2.53  | 2.46  | 2.42  | 2.38  | 2.34  | 2.30  | 2.25  | 2.21     |
| 14                                              | 4.60                                  | 3.74  | 3.34  | 3.11  | 2.96  | 2.85  | 2.76  | 2.70  | 2.65  | 2.60  | 2.53  | 2.46  | 2.39  | 2.35  | 2.31  | 2.27  | 2.22  | 2.18  | 2.13     |
| 15                                              | 4.54                                  | 3.68  | 3.29  | 3.06  | 2.90  | 2.79  | 2.71  | 2.64  | 2.59  | 2.54  | 2.48  | 2.40  | 2.33  | 2.29  | 2.25  | 2.20  | 2.16  | 2.11  | 2.07     |
| 16                                              | 4.49                                  | 3.63  | 3.24  | 3.01  | 2.85  | 2.74  | 2.66  | 2.59  | 2.54  | 2.49  | 2.42  | 2.35  | 2.28  | 2.24  | 2.19  | 2.15  | 2.10  | 2.06  | 2.01     |
| 17                                              | 4.45                                  | 3.59  | 3.20  | 2.96  | 2.81  | 2.70  | 2.61  | 2.55  | 2.49  | 2.45  | 2.38  | 2.31  | 2.23  | 2.19  | 2.15  | 2.10  | 2.06  | 2.01  | 1.96     |
| 18                                              | 4.41                                  | 3.55  | 3.16  | 2.93  | 2.77  | 2.66  | 2.58  | 2.51  | 2.46  | 2.41  | 2.34  | 2.27  | 2.19  | 2.15  | 2.11  | 2.06  | 2.02  | 1.97  | 1.92     |
| 19                                              | 4.38                                  | 3.52  | 3.13  | 2.90  | 2.74  | 2.63  | 2.54  | 2.48  | 2.42  | 2.38  | 2.31  | 2.23  | 2.16  | 2.11  | 2.07  | 2.03  | 1.98  | 1.93  | 1.88     |
| 20                                              | 4.35                                  | 3.49  | 3.10  | 2.87  | 2.71  | 2.60  | 2.51  | 2.45  | 2.39  | 2.35  | 2.28  | 2.20  | 2.12  | 2.08  | 2.04  | 1.99  | 1.95  | 1.90  | 1.84     |
| 21                                              | 4.32                                  | 3.47  | 3.07  | 2.84  | 2.68  | 2.57  | 2.49  | 2.42  | 2.37  | 2.32  | 2.25  | 2.18  | 2.10  | 2.05  | 2.01  | 1.96  | 1.92  | 1.87  | 1.81     |
| 22                                              | 4.30                                  | 3.44  | 3.05  | 2.82  | 2.66  | 2.55  | 2.46  | 2.40  | 2.34  | 2.30  | 2.23  | 2.15  | 2.07  | 2.03  | 1.98  | 1.94  | 1.89  | 1.84  | 1.78     |
| 23                                              | 4.28                                  | 3.42  | 3.03  | 2.80  | 2.64  | 2.53  | 2.44  | 2.37  | 2.32  | 2.27  | 2.20  | 2.13  | 2.05  | 2.01  | 1.96  | 1.91  | 1.86  | 1.81  | 1.76     |
| 24                                              | 4.26                                  | 3.40  | 3.01  | 2.78  | 2.62  | 2.51  | 2.42  | 2.36  | 2.30  | 2.25  | 2.18  | 2.11  | 2.03  | 1.98  | 1.94  | 1.89  | 1.84  | 1.79  | 1.73     |
| 25                                              | 4.24                                  | 3.39  | 2.99  | 2.76  | 2.60  | 2.49  | 2.40  | 2.34  | 2.28  | 2.24  | 2.16  | 2.09  | 2.01  | 1.96  | 1.92  | 1.87  | 1.82  | 1.77  | 1.71     |
| 26                                              | 4.23                                  | 3.37  | 2.98  | 2.74  | 2.59  | 2.47  | 2.39  | 2.32  | 2.27  | 2.22  | 2.15  | 2.07  | 1.99  | 1.95  | 1.90  | 1.85  | 1.80  | 1.75  | 1.69     |
| 27                                              | 4.21                                  | 3.35  | 2.96  | 2.73  | 2.57  | 2.46  | 2.37  | 2.31  | 2.25  | 2.20  | 2.13  | 2.06  | 1.97  | 1.93  | 1.88  | 1.84  | 1.79  | 1.73  | 1.67     |
| 28                                              | 4.20                                  | 3.34  | 2.95  | 2.71  | 2.56  | 2.45  | 2.36  | 2.29  | 2.24  | 2.19  | 2.12  | 2.04  | 1.96  | 1.91  | 1.87  | 1.82  | 1.77  | 1.71  | 1.65     |
| 29                                              | 4.18                                  | 3.33  | 2.93  | 2.70  | 2.55  | 2.43  | 2.35  | 2.28  | 2.22  | 2.18  | 2.10  | 2.03  | 1.94  | 1.90  | 1.85  | 1.81  | 1.75  | 1.70  | 1.64     |
| 30                                              | 4.17                                  | 3.32  | 2.92  | 2.69  | 2.53  | 2.42  | 2.33  | 2.27  | 2.21  | 2.16  | 2.09  | 2.01  | 1.93  | 1.89  | 1.84  | 1.79  | 1.74  | 1.68  | 1.62     |
| 40                                              | 4.08                                  | 3.23  | 2.84  | 2.61  | 2.45  | 2.34  | 2.25  | 2.18  | 2.12  | 2.08  | 2.00  | 1.92  | 1.84  | 1.79  | 1.74  | 1.69  | 1.64  | 1.58  | 1.51     |
| 60                                              | 4.00                                  | 3.15  | 2.76  | 2.53  | 2.37  | 2.25  | 2.17  | 2.10  | 2.04  | 1.99  | 1.92  | 1.84  | 1.75  | 1.70  | 1.65  | 1.59  | 1.53  | 1.47  | 1.39     |
| 120                                             | 3.92                                  | 3.07  | 2.68  | 2.45  | 2.29  | 2.17  | 2.09  | 2.02  | 1.96  | 1.91  | 1.83  | 1.75  | 1.66  | 1.61  | 1.55  | 1.50  | 1.43  | 1.35  | 1.25     |
| $\infty$                                        | 3.84                                  | 3.00  | 2.60  | 2.37  | 2.21  | 2.10  | 2.01  | 1.94  | 1.88  | 1.83  | 1.75  | 1.67  | 1.57  | 1.52  | 1.46  | 1.39  | 1.32  | 1.22  | 1.00     |



Table H (concluded)

| d.f.D.:<br>Degrees of<br>freedom,<br>denominator |       | d.f.N.: Degrees of freedom, numerator |       |       |       |       |       |       |       |       |       |       |       |       |       |       | $\alpha = 0.10$ |       |       |          |
|--------------------------------------------------|-------|---------------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-----------------|-------|-------|----------|
|                                                  |       | 1                                     | 2     | 3     | 4     | 5     | 6     | 7     | 8     | 9     | 10    | 12    | 15    | 20    | 24    | 30    | 40              | 60    | 120   | $\infty$ |
| 1                                                | 39.86 | 49.50                                 | 53.59 | 55.83 | 57.24 | 58.20 | 58.91 | 59.44 | 59.86 | 60.19 | 60.71 | 61.22 | 61.74 | 62.00 | 62.26 | 62.53 | 62.79           | 63.06 | 63.33 |          |
| 2                                                | 8.53  | 9.00                                  | 9.16  | 9.24  | 9.29  | 9.33  | 9.35  | 9.37  | 9.38  | 9.39  | 9.41  | 9.42  | 9.44  | 9.45  | 9.46  | 9.47  | 9.47            | 9.48  | 9.49  |          |
| 3                                                | 5.54  | 5.46                                  | 5.39  | 5.34  | 5.31  | 5.28  | 5.27  | 5.25  | 5.24  | 5.23  | 5.22  | 5.20  | 5.18  | 5.18  | 5.17  | 5.16  | 5.15            | 5.14  | 5.13  |          |
| 4                                                | 4.54  | 4.32                                  | 4.19  | 4.11  | 4.05  | 4.01  | 3.98  | 3.95  | 3.94  | 3.92  | 3.90  | 3.87  | 3.84  | 3.83  | 3.82  | 3.80  | 3.79            | 3.78  | 3.76  |          |
| 5                                                | 4.06  | 3.78                                  | 3.62  | 3.52  | 3.45  | 3.40  | 3.37  | 3.34  | 3.32  | 3.30  | 3.27  | 3.24  | 3.21  | 3.19  | 3.17  | 3.16  | 3.14            | 3.12  | 3.10  |          |
| 6                                                | 3.78  | 3.46                                  | 3.29  | 3.18  | 3.11  | 3.05  | 3.01  | 2.98  | 2.96  | 2.94  | 2.90  | 2.87  | 2.84  | 2.82  | 2.80  | 2.78  | 2.76            | 2.74  | 2.72  |          |
| 7                                                | 3.59  | 3.26                                  | 3.07  | 2.96  | 2.88  | 2.83  | 2.78  | 2.75  | 2.72  | 2.70  | 2.67  | 2.63  | 2.59  | 2.58  | 2.56  | 2.54  | 2.51            | 2.49  | 2.47  |          |
| 8                                                | 3.46  | 3.11                                  | 2.92  | 2.81  | 2.73  | 2.67  | 2.62  | 2.59  | 2.56  | 2.54  | 2.50  | 2.46  | 2.42  | 2.40  | 2.38  | 2.36  | 2.34            | 2.32  | 2.29  |          |
| 9                                                | 3.36  | 3.01                                  | 2.81  | 2.69  | 2.61  | 2.55  | 2.51  | 2.47  | 2.44  | 2.42  | 2.38  | 2.34  | 2.30  | 2.28  | 2.25  | 2.23  | 2.21            | 2.18  | 2.16  |          |
| 10                                               | 3.29  | 2.92                                  | 2.73  | 2.61  | 2.52  | 2.46  | 2.41  | 2.38  | 2.35  | 2.32  | 2.28  | 2.24  | 2.20  | 2.18  | 2.16  | 2.13  | 2.11            | 2.08  | 2.06  |          |
| 11                                               | 3.23  | 2.86                                  | 2.66  | 2.54  | 2.45  | 2.39  | 2.34  | 2.30  | 2.27  | 2.25  | 2.21  | 2.17  | 2.12  | 2.10  | 2.08  | 2.05  | 2.03            | 2.00  | 1.97  |          |
| 12                                               | 3.18  | 2.81                                  | 2.61  | 2.48  | 2.39  | 2.33  | 2.28  | 2.24  | 2.21  | 2.19  | 2.15  | 2.10  | 2.05  | 2.04  | 2.01  | 1.99  | 1.96            | 1.93  | 1.90  |          |
| 13                                               | 3.14  | 2.76                                  | 2.56  | 2.43  | 2.35  | 2.28  | 2.23  | 2.20  | 2.16  | 2.14  | 2.10  | 2.05  | 2.01  | 1.98  | 1.96  | 1.91  | 1.89            | 1.86  | 1.83  |          |
| 14                                               | 3.10  | 2.73                                  | 2.52  | 2.39  | 2.31  | 2.24  | 2.19  | 2.15  | 2.12  | 2.10  | 2.05  | 2.01  | 1.96  | 1.94  | 1.91  | 1.87  | 1.85            | 1.82  | 1.79  |          |
| 15                                               | 3.07  | 2.70                                  | 2.49  | 2.36  | 2.27  | 2.21  | 2.16  | 2.12  | 2.09  | 2.06  | 2.02  | 1.97  | 1.92  | 1.90  | 1.87  | 1.83  | 1.81            | 1.78  | 1.75  |          |
| 16                                               | 3.05  | 2.67                                  | 2.46  | 2.33  | 2.24  | 2.18  | 2.13  | 2.09  | 2.06  | 2.03  | 1.99  | 1.94  | 1.89  | 1.87  | 1.84  | 1.81  | 1.78            | 1.75  | 1.72  |          |
| 17                                               | 3.03  | 2.64                                  | 2.44  | 2.31  | 2.22  | 2.15  | 2.10  | 2.06  | 2.03  | 2.00  | 1.96  | 1.91  | 1.86  | 1.84  | 1.81  | 1.77  | 1.75            | 1.72  | 1.69  |          |
| 18                                               | 3.01  | 2.62                                  | 2.42  | 2.29  | 2.20  | 2.13  | 2.08  | 2.04  | 2.00  | 1.98  | 1.93  | 1.89  | 1.84  | 1.81  | 1.78  | 1.74  | 1.71            | 1.68  | 1.66  |          |
| 19                                               | 2.99  | 2.61                                  | 2.40  | 2.27  | 2.18  | 2.11  | 2.06  | 2.02  | 1.98  | 1.96  | 1.91  | 1.86  | 1.81  | 1.79  | 1.76  | 1.73  | 1.70            | 1.67  | 1.63  |          |
| 20                                               | 2.97  | 2.59                                  | 2.38  | 2.25  | 2.16  | 2.09  | 2.04  | 2.00  | 1.96  | 1.94  | 1.89  | 1.84  | 1.79  | 1.77  | 1.74  | 1.71  | 1.68            | 1.64  | 1.61  |          |
| 21                                               | 2.96  | 2.57                                  | 2.36  | 2.23  | 2.14  | 2.08  | 2.02  | 1.98  | 1.95  | 1.92  | 1.87  | 1.83  | 1.78  | 1.75  | 1.72  | 1.69  | 1.66            | 1.62  | 1.59  |          |
| 22                                               | 2.95  | 2.56                                  | 2.35  | 2.22  | 2.13  | 2.06  | 2.01  | 1.97  | 1.93  | 1.90  | 1.86  | 1.81  | 1.76  | 1.73  | 1.70  | 1.67  | 1.64            | 1.60  | 1.57  |          |
| 23                                               | 2.94  | 2.55                                  | 2.34  | 2.21  | 2.11  | 2.05  | 1.99  | 1.95  | 1.92  | 1.89  | 1.84  | 1.80  | 1.74  | 1.72  | 1.69  | 1.66  | 1.62            | 1.59  | 1.55  |          |
| 24                                               | 2.93  | 2.54                                  | 2.33  | 2.19  | 2.10  | 2.04  | 1.98  | 1.94  | 1.91  | 1.88  | 1.83  | 1.78  | 1.73  | 1.70  | 1.67  | 1.64  | 1.61            | 1.57  | 1.53  |          |
| 25                                               | 2.92  | 2.53                                  | 2.32  | 2.18  | 2.09  | 2.02  | 1.97  | 1.93  | 1.89  | 1.87  | 1.82  | 1.77  | 1.72  | 1.69  | 1.66  | 1.63  | 1.59            | 1.56  | 1.52  |          |
| 26                                               | 2.91  | 2.52                                  | 2.31  | 2.17  | 2.08  | 2.01  | 1.96  | 1.92  | 1.88  | 1.86  | 1.81  | 1.76  | 1.71  | 1.68  | 1.65  | 1.61  | 1.58            | 1.54  | 1.50  |          |
| 27                                               | 2.90  | 2.51                                  | 2.30  | 2.17  | 2.07  | 2.00  | 1.95  | 1.91  | 1.87  | 1.85  | 1.80  | 1.75  | 1.70  | 1.67  | 1.64  | 1.60  | 1.57            | 1.53  | 1.49  |          |
| 28                                               | 2.89  | 2.50                                  | 2.29  | 2.16  | 2.06  | 2.00  | 1.94  | 1.90  | 1.87  | 1.84  | 1.79  | 1.74  | 1.69  | 1.66  | 1.63  | 1.59  | 1.56            | 1.52  | 1.48  |          |
| 29                                               | 2.89  | 2.50                                  | 2.28  | 2.15  | 2.06  | 1.99  | 1.93  | 1.89  | 1.86  | 1.83  | 1.78  | 1.73  | 1.68  | 1.65  | 1.62  | 1.58  | 1.55            | 1.51  | 1.47  |          |
| 30                                               | 2.88  | 2.49                                  | 2.28  | 2.14  | 2.05  | 1.98  | 1.93  | 1.88  | 1.85  | 1.82  | 1.77  | 1.72  | 1.67  | 1.64  | 1.61  | 1.57  | 1.54            | 1.50  | 1.46  |          |
| 40                                               | 2.84  | 2.44                                  | 2.23  | 2.09  | 2.00  | 1.93  | 1.87  | 1.83  | 1.79  | 1.76  | 1.71  | 1.66  | 1.61  | 1.57  | 1.54  | 1.51  | 1.47            | 1.42  | 1.38  |          |
| 60                                               | 2.79  | 2.39                                  | 2.18  | 2.04  | 1.95  | 1.87  | 1.82  | 1.77  | 1.74  | 1.71  | 1.66  | 1.60  | 1.54  | 1.51  | 1.48  | 1.44  | 1.40            | 1.35  | 1.29  |          |
| 120                                              | 2.75  | 2.35                                  | 2.13  | 1.99  | 1.90  | 1.82  | 1.77  | 1.72  | 1.68  | 1.65  | 1.60  | 1.55  | 1.48  | 1.45  | 1.41  | 1.37  | 1.32            | 1.26  | 1.19  |          |
| $\infty$                                         | 2.71  | 2.30                                  | 2.08  | 1.94  | 1.85  | 1.77  | 1.72  | 1.67  | 1.63  | 1.60  | 1.55  | 1.49  | 1.42  | 1.38  | 1.34  | 1.30  | 1.24            | 1.17  | 1.00  |          |



**Table I** Critical Values for PPMC

Reject  $H_0: \rho = 0$  if the absolute value of  $r$  is greater than the value given in the table. The values are for a two-tailed test; d.f. =  $n - 2$ .

| d.f. | $\alpha = 0.05$ | $\alpha = 0.01$ |
|------|-----------------|-----------------|
| 1    | 0.999           | 0.999           |
| 2    | 0.950           | 0.999           |
| 3    | 0.878           | 0.959           |
| 4    | 0.811           | 0.917           |
| 5    | 0.754           | 0.875           |
| 6    | 0.707           | 0.834           |
| 7    | 0.666           | 0.798           |
| 8    | 0.632           | 0.765           |
| 9    | 0.602           | 0.735           |
| 10   | 0.576           | 0.708           |
| 11   | 0.553           | 0.684           |
| 12   | 0.532           | 0.661           |
| 13   | 0.514           | 0.641           |
| 14   | 0.497           | 0.623           |
| 15   | 0.482           | 0.606           |
| 16   | 0.468           | 0.590           |
| 17   | 0.456           | 0.575           |
| 18   | 0.444           | 0.561           |
| 19   | 0.433           | 0.549           |
| 20   | 0.423           | 0.537           |
| 25   | 0.381           | 0.487           |
| 30   | 0.349           | 0.449           |
| 35   | 0.325           | 0.418           |
| 40   | 0.304           | 0.393           |
| 45   | 0.288           | 0.372           |
| 50   | 0.273           | 0.354           |
| 60   | 0.250           | 0.325           |
| 70   | 0.232           | 0.302           |
| 80   | 0.217           | 0.283           |
| 90   | 0.205           | 0.267           |
| 100  | 0.195           | 0.254           |

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