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[This question paper contains 20 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 4386

C

Unique Paper Code : 12273303

Name of the Paper : Data Analysis (SEC)

Name of the Course : B.A. (H) Economics

Semester : III

Duration : 3 Hours

Maximum Marks : 65

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. This question paper has **two** sections. Attempt any **TWO** questions from each section.
3. You do not require the use of R or Excel software to answer any question. Wherever asked, mention/discuss the command/function/syntax, as required in the question.
4. The questions in which R or Excel is not mentioned, the answers should be based on your own calculations.
5. Use of a simple non-programmable calculator is allowed.
6. Statistical tables are attached for your reference.
7. Answers may be written either in English or Hindi; but the same medium should be used throughout the paper.

छात्रों के लिए निर्देश

1. इस प्रश्न-पत्र के मिलते ही ऊपर दिए गए निर्धारित स्थान पर अपना अनुक्रमांक लिखिए।
2. इस प्रश्न पत्र में दो खंड हैं। प्रत्येक खंड से कोई दो प्रश्न हल करें।
3. आपको किसी भी प्रश्न का उत्तर देने के लिए R या एक्सेल सॉफ्टवेयर के उपयोग की आवश्यकता नहीं है। जहां भी पूछा गया हो, प्रश्न में आवश्यक कमांड/फंक्शन/वाक्यविन्यास का उल्लेख/चर्चा करें।
4. जिन प्रश्नों में या एक्सेल का उल्लेख नहीं है, उनके उत्तर आपकी अपनी गणना पर आधारित होने चाहिए।
5. एक साधारण गैर-प्रोग्रामयोग्य कैलकुलेटर के उपयोग की अनुमति है।
6. आपके संदर्भ के लिए सांख्यिकीय सारणियां संलग्न हैं।
7. इस प्रश्न-पत्र का उत्तर अंग्रेजी या हिंदी किसी एक भाषा में दीजिए, लेकिन सभी उत्तरों का माध्यम एक ही होना चाहिए।

P.T.O.

SECTION A

1. (a) A college professor needs to determine the average spending by students of her college. To conduct this research, she chooses a sample of 30 students from her own course.

(i) Which sampling method has been used by the professor? Critically discuss the advantages and disadvantages of this method. (4)

(ii) Is the sample selected by the professor a true representative of the entire population? Why or why not? (3)

(iii) Suppose three courses are offered by the college. What sampling method should be used to ensure students' representation from all the three courses? Explain. (3)

(b) Explain the command used for calculating a 10% trimmed mean in R. (3)

(c) Explain the Excel function used to calculate Skewness and Kurtosis. (3)

(क) एक कॉलेज के प्रोफेसर को अपने कॉलेज के छात्रों द्वारा औसत खर्च का निर्धारण करना है। इस शोध को करने के लिए वह अपने पाठ्यक्रम से 30 छात्रों का एक प्रतिदर्श चुनती है।

(i) प्रोफेसर द्वारा किस प्रतिदर्श की विधि का उपयोग किया गया है? इस विधि के लाभ और हानि की आलोचनात्मक विवेचना कीजिए।

(ii) क्या प्रोफेसर द्वारा चुना गया प्रतिदर्श पूरी आबादी का सच्चा प्रतिनिधि है? क्यों या क्यों नहीं?

(iii) मान लीजिए कि कॉलेज द्वारा तीन पाठ्यक्रम उपलब्ध कराए जाते हैं। तीनों पाठ्यक्रमों से छात्रों का प्रतिनिधित्व सुनिश्चित करने के लिए किस प्रतिदर्श पद्धति का उपयोग किया जाना चाहिए? व्याख्या करें।

(ख) R में 10% ट्रिम किए गए माध्य की गणना के लिए उपयोग की जाने वाली कमांड की व्याख्या करें।

(ग) विषमता और पृथुशीर्षत्व की गणना के लिए प्रयुक्त एक्सेल फंक्शन की व्याख्या करें।

2. (a) Consider a traffic controller recording the number of trucks passing through a bridge every evening for a month. The average number of trucks passing through the bridge is 600, and standard deviation is 30. Suppose the shape of the population is unknown.

(i) Explain Chebyshev's theorem. Use it to determine the percentage of evenings in which the number of trucks passing through the bridge are between 480 and 720. (6)

(ii) How likely is it for the number of trucks passing through the bridge on any evening to be less than 540? (4)

(b) Write the R command to obtain an urn of balls containing two balls of each of the three colours: red, yellow and pink. (3)

(c) Explain the Excel function used to round off the number 3.456 to the lowest integer. How does the function change if you have to round off this number to the highest integer? (3)

(क) एक महीने के लिए हर शाम एक पुत्र से गुजरने वाले ट्रकों की संख्या रिकॉर्ड करने वाले यातायात नियंत्रक पर विचार करें। पुल से गुजरने वाले ट्रकों की औसत संख्या 600 है, और मानक विचलन 30 है। मान लीजिए कि जनसंख्या का आकार अज्ञात है।

(i) चेबीशेव के प्रमेय की व्याख्या कीजिए। इसका उपयोग करते हुए निर्धारित करें कि कितने प्रतिशत शामों में पुल से गुजरने वाले ट्रकों की संख्या 480 और 720 के बीच है।

(ii) किसी शाम को पुल से गुजरने वाले ट्रकों की संख्या 540 से कम होने की कितनी संभावना है?

(ख) गेंदों का एक कलश प्राप्त करने के लिए R कमांड लिखें जिसमें इन तीनों रंगों में से प्रत्येक की दो - दो गेंदें हों : लाल, पीला और गुलाबी।

(ग) संख्या 3.456 को निम्नतम पूर्णांक में पूर्णांकित करने के लिए प्रयुक्त एक्सेल फंक्शन की व्याख्या करें। यदि आपको इस संख्या को उच्चतम पूर्णांक में पूर्णांकित करना है तो फंक्शन कैसे बदलता है?

3. (a) 80 students of Class Vth in a school appeared for Math and English tests. Following are the marks of a sample of 5 students who appeared for the test :

Mathematics	80	76	99	75	55
English	75	80	95	69	50

- (i) Compute the sample coefficient of correlation between marks in Mathematics and English. Interpret your results. (5)

(ii) Calculate the Z scores of Mathematics marks. Are there any outliers? (5)

(b) Suppose a University adopts the following grading system for conversion of marks to grades :

Marks	Above 80	65-80	Below 65
Grade s	A	B	C

Write the Excel command to recode the "marks" variable into grades using IF function. Present the data in (a) in the form of grades. (3)

(c) Suppose you are given the following data: 9, -5, 3, 7, -10, -12, 19, -4, 1, -6, -22. Write R command to figure out the positions at which the numbers are less than zero. (3)

(क) एक स्कूल में पांचवी कक्षा के 80 छात्र गणित और अंग्रेजी की परीक्षा के लिए उपस्थित हुए। परीक्षण के लिए उपस्थित हुए सभी छात्रों में से 5 छात्रों का प्रतिदर्श लिया गया, जिनके अंक निम्नलिखित हैं :

गणित	80	76	99	75	55
अंग्रेजी	75	80	95	69	50

(i) गणित और अंग्रेजी में अंकों के बीच सहसंबंध के प्रतिदर्श गुणांक की गणना करें। अपने परिणामों की व्याख्या करें।

(ii) गणित के अंकों के Z स्कोर की गणना करें। क्या कोई आउटलायर हैं?

(ख) मान लीजिए कि विश्वविद्यालय अंकों को ग्रेड में बदलने के लिए निम्नलिखित ग्रेडिंग प्रणाली अपनाता है :

अंक	80 से ऊपर	65-80	65 से नीचे
ग्रेड	A	B	C

IF फंक्शन का उपयोग करके "अंक" चर को ग्रेड में फिर से कोड करने के लिए एक्सेल कमांड लिखें। आँकड़ों को (a) ग्रेड के रूप में प्रस्तुत करें।

(ग) मान लीजिए आपको निम्नलिखित आंकड़े दिए गए हैं : 9, -5, 3, 7, -10, -12, 19, -4, 1, -6, -22। जिन पदों पर संख्याएँ शून्य से कम हैं, उनका पता लगाने के लिए R कमांड लिखें।

SECTION B

4. (a) Consider a harbour where ships either arrive on time or they arrive late as per their scheduled timings. If on an average, one out of 10 ships arrives late, find the probability that out of a total of 5 ships scheduled for any single day, at least 4 will arrive on time. (5)

- (b) Explain the Excel function that can be used to calculate the probability in (a). (3)
- (c) A soap manufacturing company was distributing a particular brand of soap through a large number of retail shops. Before a heavy advertisement campaign, the mean sales per week per shop was 140 dozen. After the advertisement campaign, a sample of 26 shops was taken and the mean sales per week was found to be 147 dozen with standard deviation of 16 dozen. At 5% significance level, can you say that sales have increased because of the advertisement campaign? Why or why not? (5)
- (d) Suppose data on sales of soaps for these 26 shops in Part (c) is stored in R. Explain the R command for testing the hypothesis in (c). (3.5)
- (क) एक बंदरगाह पर विचार करें जहां जहाज या तो निर्धारित समय पर पहुंचते हैं या वे विलंब से पहुंचते हैं। यदि औसतन 10 में से एक जहाज देरी से आता है, तो किसी एक दिन के लिए निर्धारित कुल 5 जहाजों में से कम से कम 4 के समय पर पहुंचने की प्रायिकता ज्ञात कीजिए।
- (ख) एक्सेल फंक्शन की व्याख्या करें जिसका उपयोग (a) में प्रायिकता की गणना के लिए किया जा सकता है।
- (ग) एक साबुन बनाने वाली कंपनी बड़ी संख्या में खुदरा दुकानों के माध्यम से एक विशेष ब्रांड के साबुन का वितरण कर रही थी। एक भारी विज्ञापन अभियान से पहले, प्रति सप्ताह प्रति दुकान औसत बिक्री 140 दर्जन थी। विज्ञापन अभियान के बाद, 26 दुकानों का प्रतिदर्श लिया गया और प्रति सप्ताह औसत बिक्री 147 दर्जन पाई गई और मानक विचलन 16 दर्जन पाया गया। 5% महत्व स्तर पर, क्या आप कह सकते हैं कि विज्ञापन अभियान के कारण बिक्री में वृद्धि हुई है? क्यों या क्यों नहीं ?

(घ) मान लीजिए कि भाग (ग) में इन 26 दुकानों के लिए साबुन की बिक्री पर डेटा R में संग्रहीत है। (ग) में परिकल्पना के परीक्षण के लिए R कमांड की व्याख्या करें।

5. (a) In a sample of 400 parts manufactured by a factory, the number of defective parts was found to be 30. The company, however, claimed that 2% of their manufactured products are defective. Check if the company's claim is tenable at 5% level of significance. Interpret your results. (5)
- (b) A potential buyer took a random sample of 9 electric bulbs of brand A and 9 electric bulbs of brand B. Upon testing, he found that Brand A had a mean life of 250 hours with a standard deviation of 40 hours whereas Brand B had a mean life of 220 hours with a standard deviation of 55 hours. Answer the following questions:
- (i) Write the null and alternative hypotheses to test whether there is any difference in the average bulb quality between brands A and B. (2)
- (ii) For this hypothesis, compute the value of the pooled sample variance and pooled variance t -test statistic. (3)
- (iii) Is the data consistent with the hypothesis that the two brands do not differ significantly in quality at 5% level of significance? (2)
- (c) Suppose the data on weight of rice bags which ranges from 5kg to 100kg is stored in a data vector in R, named *Ricebag*. Explain the R command(s) for constructing a neatly labeled and colourful histogram,

with unequal bins. Following are the breakpoints for the bins: 10, 20, 40, and 90 Kg. (4.5)

For visually impaired students, in lieu of 5(c): Explain the use of Is command in R with the help of examples. (4.5)

- (क) एक कारखाने द्वारा निर्मित 400 पार्ट्स के एक प्रतिदर्श में, दोषपूर्ण पार्ट्स की संख्या 30 पाई गई थी। हालांकि, कंपनी ने दावा किया कि उनके निर्मित उत्पादों में से 2% दोषपूर्ण हैं। जाँच करें कि क्या कंपनी का दावा 5% महत्व के स्तर पर मान्य है। अपने परिणामों की व्याख्या करें।
- (ख) एक संभावित खरीदार ने ब्रांड A के 9 बिजली के बल्ब और ब्रांड B के 9 बिजली के बल्बों का यादृच्छिक प्रतिदर्श लिया। परीक्षण करने पर उन्होंने पाया कि ब्रांड A का 40 घंटे के मानक विचलन के साथ औसत जीवन 250 घंटे का था जबकि ब्रांड B का 55 घंटे के मानक विचलन के साथ 220 घंटे का औसत जीवन था। निम्नलिखित प्रश्नों के उत्तर दीजिए :
- ब्रांड A और B के बीच औसत बल्ब गुणवत्ता में कोई अंतर है या नहीं यह जांचने के लिए शून्य और वैकल्पिक परिकल्पना लिखें।
 - इस परिकल्पना के लिए, पूलड सैंपल प्रसरण और पूलड प्रसरण t परीक्षण आंकड़ों के मूल्य की गणना करें।
 - क्या डेटा इस परिकल्पना के अनुरूप है कि दोनों ब्रांड 5% महत्व के स्तर पर गुणवत्ता में महत्वपूर्ण रूप से भिन्न नहीं हैं?
- (ग) मान लीजिए चावल बैग के वजन पर डेटा जो 5 किलो से 100 किलो तक में है, R में डेटा वेक्टर में संग्रहीत किया जाता है, जिसे *Ricebag* कहा जाता है। असमान डिब्बों के साथ एक साफ-सुथरे

लेबल वाले और रंगीन हिस्टोग्राम के निर्माण के लिए R कमांड की व्याख्या करें। डिब्बे के लिए ब्रेकप्वाइंट निम्नलिखित हैं : 10, 20, 40, और 90 किलो।

दृष्टिबाधित छात्रों के लिए, 5(ग) के स्थान पर : R में ls कमांड के उपयोग को उदाहरणों की सहायता से समझाइए।

6. (a) The average number of tons of sugar sold in 5 countries in January 2020 are as follows:

174, 161, 167, 171, 163, 141, 147, 154. Calculate the median, minimum, maximum, Q1 and Q3. Is the data skewed? (6)

- (b) Explain the meaning of power of a test. (2)

- (c) In an inspection by Weights and Measures Department to measure the quantity of water filled in 2-liter water bottles, the inspector wants the mean amount of water filled in these bottles to lie within ± 0.01 litre with 95% confidence level. What sample size is needed for the same? Assume standard deviation to be 0.05 litre. (4)

- (d) Explain the use of Excel functions F.INV.RT() and F.DIST.RT() with the help of examples. (4.5)

(क) जनवरी 2020 में 5 देशों में बेची गई चीनी की औसत संख्या इस प्रकार है : 174, 161, 167, 171, 163, 141, 147, 154. माध्यिका, न्यूनतम, अधिकतम, Q1, और Q3 की गणना करें। क्या डेटा विषम है?

(ख) एक परीक्षण की शक्ति का अर्थ स्पष्ट करें।

(ग) बाट और माप विभाग द्वारा 2 लीटर पानी की बोतलों में भरे पानी की मात्रा को मापने के लिए एक निरीक्षण में, निरीक्षक चाहता है कि इन बोतलों में भरे पानी की औसत मात्रा ± 0.01 लीटर के भीतर 95% कॉन्फिडेंस स्तर के साथ हो। उसी के लिए किस नमूना आकार की आवश्यकता है? मान लें कि मानक विचलन 0.05 लीटर है।

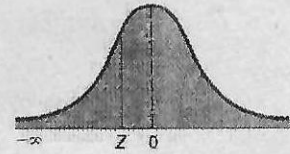
(घ) एक्सेल फंक्शन F.INV.RT() और F.DIST.RT() के उपयोग को उदाहरणों की सहायता से समझाइए।

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664 APPENDICES

TABLE E.2

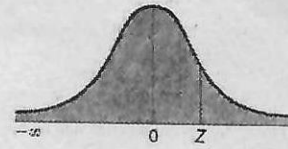
The Cumulative Standardized Normal Distribution

Entry represents area under the cumulative standardized normal distribution from $-\infty$ to Z 

Cumulative Probabilities										
Z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
-6.0	0.00000001									
-5.5	0.000000019									
-5.0	0.000000287									
-4.5	0.000003398									
-4.0	0.000031671									
-3.9	0.00005	0.00005	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00003	0.00003
-3.8	0.00007	0.00007	0.00007	0.00006	0.00006	0.00006	0.00006	0.00005	0.00005	0.00005
-3.7	0.00011	0.00010	0.00010	0.00010	0.00009	0.00009	0.00008	0.00008	0.00008	0.00008
-3.6	0.00016	0.00015	0.00015	0.00014	0.00014	0.00013	0.00013	0.00012	0.00012	0.00011
-3.5	0.00023	0.00022	0.00022	0.00021	0.00020	0.00019	0.00019	0.00018	0.00017	0.00017
-3.4	0.00034	0.00032	0.00031	0.00030	0.00029	0.00028	0.00027	0.00026	0.00025	0.00024
-3.3	0.00048	0.00047	0.00045	0.00043	0.00042	0.00040	0.00039	0.00038	0.00036	0.00035
-3.2	0.00069	0.00066	0.00064	0.00062	0.00060	0.00058	0.00056	0.00054	0.00052	0.00050
-3.1	0.00097	0.00094	0.00090	0.00087	0.00084	0.00082	0.00079	0.00076	0.00074	0.00071
-3.0	0.00135	0.00131	0.00126	0.00122	0.00118	0.00114	0.00111	0.00107	0.00103	0.00100
-2.9	0.0019	0.0018	0.0018	0.0017	0.0016	0.0016	0.0015	0.0015	0.0014	0.0014
-2.8	0.0026	0.0025	0.0024	0.0023	0.0023	0.0022	0.0021	0.0021	0.0020	0.0019
-2.7	0.0035	0.0034	0.0033	0.0032	0.0031	0.0030	0.0029	0.0028	0.0027	0.0026
-2.6	0.0047	0.0045	0.0044	0.0043	0.0041	0.0040	0.0039	0.0038	0.0037	0.0036
-2.5	0.0062	0.0060	0.0059	0.0057	0.0055	0.0054	0.0052	0.0051	0.0049	0.0048
-2.4	0.0082	0.0080	0.0078	0.0075	0.0073	0.0071	0.0069	0.0068	0.0066	0.0064
-2.3	0.0107	0.0104	0.0102	0.0099	0.0096	0.0094	0.0091	0.0089	0.0087	0.0084
-2.2	0.0139	0.0136	0.0132	0.0129	0.0125	0.0122	0.0119	0.0116	0.0113	0.0110
-2.1	0.0179	0.0174	0.0170	0.0166	0.0162	0.0158	0.0154	0.0150	0.0146	0.0143
-2.0	0.0228	0.0222	0.0217	0.0212	0.0207	0.0202	0.0197	0.0192	0.0188	0.0183
-1.9	0.0287	0.0281	0.0274	0.0268	0.0262	0.0256	0.0250	0.0244	0.0239	0.0233
-1.8	0.0359	0.0351	0.0344	0.0336	0.0329	0.0322	0.0314	0.0307	0.0301	0.0294
-1.7	0.0446	0.0436	0.0427	0.0418	0.0409	0.0401	0.0392	0.0384	0.0375	0.0367
-1.6	0.0548	0.0537	0.0526	0.0516	0.0505	0.0495	0.0485	0.0475	0.0465	0.0455
-1.5	0.0668	0.0655	0.0643	0.0630	0.0618	0.0606	0.0594	0.0582	0.0571	0.0559
-1.4	0.0808	0.0793	0.0778	0.0764	0.0749	0.0735	0.0721	0.0708	0.0694	0.0681
-1.3	0.0968	0.0951	0.0934	0.0918	0.0901	0.0885	0.0869	0.0853	0.0838	0.0823
-1.2	0.1151	0.1131	0.1112	0.1093	0.1075	0.1056	0.1038	0.1020	0.1003	0.0985
-1.1	0.1357	0.1335	0.1314	0.1292	0.1271	0.1251	0.1230	0.1210	0.1190	0.1170
-1.0	0.1587	0.1562	0.1539	0.1515	0.1492	0.1469	0.1446	0.1423	0.1401	0.1379
-0.9	0.1841	0.1814	0.1788	0.1762	0.1736	0.1711	0.1685	0.1660	0.1635	0.1611
-0.8	0.2119	0.2090	0.2061	0.2033	0.2005	0.1977	0.1949	0.1922	0.1894	0.1867
-0.7	0.2420	0.2388	0.2358	0.2327	0.2296	0.2266	0.2236	0.2206	0.2177	0.2148
-0.6	0.2743	0.2709	0.2676	0.2643	0.2611	0.2578	0.2546	0.2514	0.2482	0.2451
-0.5	0.3085	0.3050	0.3015	0.2981	0.2946	0.2912	0.2877	0.2843	0.2810	0.2776
-0.4	0.3446	0.3409	0.3372	0.3336	0.3300	0.3264	0.3228	0.3192	0.3156	0.3121
-0.3	0.3821	0.3783	0.3745	0.3707	0.3669	0.3632	0.3594	0.3557	0.3520	0.3483
-0.2	0.4207	0.4168	0.4129	0.4090	0.4052	0.4013	0.3974	0.3936	0.3897	0.3859
-0.1	0.4602	0.4562	0.4522	0.4483	0.4443	0.4404	0.4364	0.4325	0.4286	0.4247
-0.0	0.5000	0.4960	0.4920	0.4880	0.4840	0.4801	0.4761	0.4721	0.4681	0.4641

TABLE E.2

The Cumulative Standardized Normal Distribution (continued)

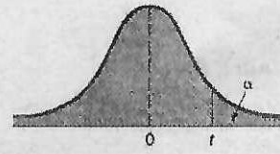
Entry represents area under the cumulative standardized normal distribution from $-\infty$ to Z 

Cumulative Probabilities										
Z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.5000	0.5040	0.5080	0.5120	0.5160	0.5199	0.5239	0.5279	0.5319	0.5359
0.1	0.5398	0.5438	0.5478	0.5517	0.5557	0.5596	0.5636	0.5675	0.5714	0.5753
0.2	0.5793	0.5832	0.5871	0.5910	0.5948	0.5987	0.6026	0.6064	0.6103	0.6141
0.3	0.6179	0.6217	0.6255	0.6293	0.6331	0.6368	0.6406	0.6443	0.6480	0.6517
0.4	0.6554	0.6591	0.6628	0.6664	0.6700	0.6736	0.6772	0.6808	0.6844	0.6879
0.5	0.6915	0.6950	0.6985	0.7019	0.7054	0.7088	0.7123	0.7157	0.7190	0.7224
0.6	0.7257	0.7291	0.7324	0.7357	0.7389	0.7422	0.7454	0.7486	0.7518	0.7549
0.7	0.7580	0.7612	0.7642	0.7673	0.7704	0.7734	0.7764	0.7794	0.7823	0.7852
0.8	0.7881	0.7910	0.7939	0.7967	0.7995	0.8023	0.8051	0.8078	0.8106	0.8133
0.9	0.8159	0.8186	0.8212	0.8238	0.8264	0.8289	0.8315	0.8340	0.8365	0.8389
1.0	0.8413	0.8438	0.8461	0.8485	0.8508	0.8531	0.8554	0.8577	0.8599	0.8621
1.1	0.8643	0.8665	0.8686	0.8708	0.8729	0.8749	0.8770	0.8790	0.8810	0.8830
1.2	0.8849	0.8869	0.8888	0.8907	0.8925	0.8944	0.8962	0.8980	0.8997	0.9015
1.3	0.9032	0.9049	0.9066	0.9082	0.9099	0.9115	0.9131	0.9147	0.9162	0.9177
1.4	0.9192	0.9207	0.9222	0.9236	0.9251	0.9265	0.9279	0.9292	0.9306	0.9319
1.5	0.9332	0.9345	0.9357	0.9370	0.9382	0.9394	0.9406	0.9418	0.9429	0.9441
1.6	0.9452	0.9463	0.9474	0.9484	0.9495	0.9505	0.9515	0.9525	0.9535	0.9545
1.7	0.9554	0.9564	0.9573	0.9582	0.9591	0.9599	0.9608	0.9616	0.9625	0.9633
1.8	0.9641	0.9649	0.9656	0.9664	0.9671	0.9678	0.9686	0.9693	0.9699	0.9706
1.9	0.9713	0.9719	0.9726	0.9732	0.9738	0.9744	0.9750	0.9756	0.9761	0.9767
2.0	0.9772	0.9778	0.9783	0.9788	0.9793	0.9798	0.9803	0.9808	0.9812	0.9817
2.1	0.9821	0.9826	0.9830	0.9834	0.9838	0.9842	0.9846	0.9850	0.9854	0.9857
2.2	0.9861	0.9864	0.9868	0.9871	0.9875	0.9878	0.9881	0.9884	0.9887	0.9890
2.3	0.9893	0.9896	0.9898	0.9901	0.9904	0.9906	0.9909	0.9911	0.9913	0.9916
2.4	0.9918	0.9920	0.9922	0.9925	0.9927	0.9929	0.9931	0.9932	0.9934	0.9936
2.5	0.9938	0.9940	0.9941	0.9943	0.9945	0.9946	0.9948	0.9949	0.9951	0.9952
2.6	0.9953	0.9955	0.9956	0.9957	0.9959	0.9960	0.9961	0.9962	0.9963	0.9964
2.7	0.9965	0.9966	0.9967	0.9968	0.9969	0.9970	0.9971	0.9972	0.9973	0.9974
2.8	0.9974	0.9975	0.9976	0.9977	0.9977	0.9978	0.9979	0.9979	0.9980	0.9981
2.9	0.9981	0.9982	0.9982	0.9983	0.9984	0.9984	0.9985	0.9985	0.9986	0.9986
3.0	0.99865	0.99869	0.99874	0.99878	0.99882	0.99886	0.99889	0.99893	0.99897	0.99900
3.1	0.99903	0.99906	0.99910	0.99913	0.99916	0.99918	0.99921	0.99924	0.99926	0.99929
3.2	0.99931	0.99934	0.99936	0.99938	0.99940	0.99942	0.99944	0.99946	0.99948	0.99950
3.3	0.99952	0.99953	0.99955	0.99957	0.99958	0.99960	0.99961	0.99962	0.99964	0.99965
3.4	0.99966	0.99968	0.99969	0.99970	0.99971	0.99972	0.99973	0.99974	0.99975	0.99976
3.5	0.99977	0.99978	0.99978	0.99979	0.99980	0.99981	0.99981	0.99982	0.99983	0.99983
3.6	0.99984	0.99985	0.99985	0.99986	0.99986	0.99987	0.99987	0.99988	0.99988	0.99989
3.7	0.99989	0.99990	0.99990	0.99990	0.99991	0.99991	0.99992	0.99992	0.99992	0.99992
3.8	0.99993	0.99993	0.99993	0.99994	0.99994	0.99994	0.99994	0.99995	0.99995	0.99995
3.9	0.99995	0.99995	0.99996	0.99996	0.99996	0.99996	0.99996	0.99996	0.99997	0.99997
4.0	0.999968329									
4.5	0.999996432									
5.0	0.999999713									
5.5	0.999999983									
6.0	0.999999998									

TABLE E.3

Critical Values of t

For a particular number of degrees of freedom, entry represents the critical value of t corresponding to the cumulative probability $(1 - \alpha)$ and a specified upper-tail area (α).



Degrees of Freedom	Cumulative Probabilities					
	0.75	0.90	0.95	0.975	0.99	0.995
	Upper Tail Area					
	0.25	0.10	0.05	0.025	0.01	0.005
1	1.0000	3.0777	6.3138	12.7062	31.8207	63.6574
2	0.8165	1.8856	2.9200	4.3027	6.9646	9.9248
3	0.7649	1.6377	2.3534	3.1824	4.5407	5.8409
4	0.7407	1.5332	2.1318	2.7764	3.7469	4.6041
5	0.7267	1.4759	2.0150	2.5706	3.3649	4.0322
6	0.7176	1.4398	1.9432	2.4469	3.1427	3.7074
7	0.7111	1.4149	1.8946	2.3646	2.9980	3.4995
8	0.7064	1.3968	1.8595	2.3060	2.8965	3.3554
9	0.7027	1.3830	1.8331	2.2622	2.8214	3.2498
10	0.6998	1.3722	1.8125	2.2281	2.7638	3.1693
11	0.6974	1.3634	1.7959	2.2010	2.7181	3.1058
12	0.6955	1.3562	1.7823	2.1788	2.6810	3.0545
13	0.6938	1.3502	1.7709	2.1604	2.6503	3.0129
14	0.6924	1.3450	1.7613	2.1448	2.6245	2.9768
15	0.6912	1.3406	1.7531	2.1315	2.6025	2.9467
16	0.6901	1.3368	1.7459	2.1199	2.5835	2.9208
17	0.6892	1.3334	1.7396	2.1098	2.5669	2.8982
18	0.6884	1.3304	1.7341	2.1009	2.5524	2.8784
19	0.6876	1.3277	1.7291	2.0930	2.5395	2.8609
20	0.6870	1.3253	1.7247	2.0860	2.5280	2.8453
21	0.6864	1.3232	1.7207	2.0796	2.5177	2.8314
22	0.6858	1.3212	1.7171	2.0739	2.5083	2.8188
23	0.6853	1.3195	1.7139	2.0687	2.4999	2.8073
24	0.6848	1.3178	1.7109	2.0639	2.4922	2.7969
25	0.6844	1.3163	1.7081	2.0595	2.4851	2.7874
26	0.6840	1.3150	1.7056	2.0555	2.4786	2.7787
27	0.6837	1.3137	1.7033	2.0518	2.4727	2.7707
28	0.6834	1.3125	1.7011	2.0484	2.4671	2.7633
29	0.6830	1.3114	1.6991	2.0452	2.4620	2.7564
30	0.6828	1.3104	1.6973	2.0423	2.4573	2.7500
31	0.6825	1.3095	1.6955	2.0395	2.4528	2.7440
32	0.6822	1.3086	1.6939	2.0369	2.4487	2.7385
33	0.6820	1.3077	1.6924	2.0345	2.4448	2.7333
34	0.6818	1.3070	1.6909	2.0322	2.4411	2.7284
35	0.6816	1.3062	1.6896	2.0301	2.4377	2.7238
36	0.6814	1.3055	1.6883	2.0281	2.4345	2.7195
37	0.6812	1.3049	1.6871	2.0262	2.4314	2.7154
38	0.6810	1.3042	1.6860	2.0244	2.4286	2.7116
39	0.6808	1.3036	1.6849	2.0227	2.4258	2.7079
40	0.6807	1.3031	1.6839	2.0211	2.4233	2.7045
41	0.6805	1.3025	1.6829	2.0195	2.4208	2.7012
42	0.6804	1.3020	1.6820	2.0181	2.4185	2.6981
43	0.6802	1.3016	1.6811	2.0167	2.4163	2.6951
44	0.6801	1.3011	1.6802	2.0154	2.4141	2.6923
45	0.6800	1.3006	1.6794	2.0141	2.4121	2.6896
46	0.6799	1.3002	1.6787	2.0129	2.4102	2.6870
47	0.6797	1.2998	1.6779	2.0117	2.4083	2.6846
48	0.6796	1.2994	1.6772	2.0106	2.4066	2.6822
49	0.6795	1.2991	1.6766	2.0096	2.4049	2.6800
50	0.6794	1.2987	1.6759	2.0086	2.4033	2.6778

TABLE E.3
Critical Values of *t* (continued)

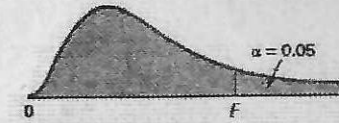
For a particular number of degrees of freedom, entry represents the critical value of *t* corresponding to the cumulative probability $(1 - \alpha)$ and a specified upper-tail area (α).

Degrees of Freedom	Cumulative Probabilities					
	0.75	0.90	0.95	0.975	0.99	0.995
	Upper-Tail Area					
	0.25	0.10	0.05	0.025	0.01	0.005
51	0.6793	1.2984	1.6753	2.0076	2.4017	2.6757
52	0.6792	1.2980	1.6747	2.0066	2.4002	2.6737
53	0.6791	1.2977	1.6741	2.0057	2.3988	2.6718
54	0.6791	1.2974	1.6736	2.0049	2.3974	2.6700
55	0.6790	1.2971	1.6730	2.0040	2.3961	2.6682
56	0.6789	1.2969	1.6725	2.0032	2.3948	2.6665
57	0.6788	1.2966	1.6720	2.0025	2.3936	2.6649
58	0.6787	1.2963	1.6716	2.0017	2.3924	2.6633
59	0.6787	1.2961	1.6711	2.0010	2.3912	2.6618
60	0.6786	1.2958	1.6706	2.0003	2.3901	2.6603
61	0.6785	1.2956	1.6702	1.9996	2.3890	2.6589
62	0.6785	1.2954	1.6698	1.9990	2.3880	2.6575
63	0.6784	1.2951	1.6694	1.9983	2.3870	2.6561
64	0.6783	1.2949	1.6690	1.9977	2.3860	2.6549
65	0.6783	1.2947	1.6686	1.9971	2.3851	2.6536
66	0.6782	1.2945	1.6683	1.9966	2.3842	2.6524
67	0.6782	1.2943	1.6679	1.9960	2.3833	2.6512
68	0.6781	1.2941	1.6676	1.9955	2.3824	2.6501
69	0.6781	1.2939	1.6672	1.9949	2.3816	2.6490
70	0.6780	1.2938	1.6669	1.9944	2.3808	2.6479
71	0.6780	1.2936	1.6666	1.9939	2.3800	2.6469
72	0.6779	1.2934	1.6663	1.9935	2.3793	2.6459
73	0.6779	1.2933	1.6660	1.9930	2.3785	2.6449
74	0.6778	1.2931	1.6657	1.9925	2.3778	2.6439
75	0.6778	1.2929	1.6654	1.9921	2.3771	2.6430
76	0.6777	1.2928	1.6652	1.9917	2.3764	2.6421
77	0.6777	1.2926	1.6649	1.9913	2.3758	2.6412
78	0.6776	1.2925	1.6646	1.9908	2.3751	2.6403
79	0.6776	1.2924	1.6644	1.9905	2.3745	2.6395
80	0.6776	1.2922	1.6641	1.9901	2.3739	2.6387
81	0.6775	1.2921	1.6639	1.9897	2.3733	2.6379
82	0.6775	1.2920	1.6636	1.9893	2.3727	2.6371
83	0.6775	1.2918	1.6634	1.9890	2.3721	2.6364
84	0.6774	1.2917	1.6632	1.9886	2.3716	2.6356
85	0.6774	1.2916	1.6630	1.9883	2.3710	2.6349
86	0.6774	1.2915	1.6628	1.9879	2.3705	2.6342
87	0.6773	1.2914	1.6626	1.9876	2.3700	2.6335
88	0.6773	1.2912	1.6624	1.9873	2.3695	2.6329
89	0.6773	1.2911	1.6622	1.9870	2.3690	2.6322
90	0.6772	1.2910	1.6620	1.9867	2.3685	2.6316
91	0.6772	1.2909	1.6618	1.9864	2.3680	2.6309
92	0.6772	1.2908	1.6616	1.9861	2.3676	2.6303
93	0.6771	1.2907	1.6614	1.9858	2.3671	2.6297
94	0.6771	1.2906	1.6612	1.9855	2.3667	2.6291
95	0.6771	1.2905	1.6611	1.9853	2.3662	2.6286
96	0.6771	1.2904	1.6609	1.9850	2.3658	2.6280
97	0.6770	1.2903	1.6607	1.9847	2.3654	2.6275
98	0.6770	1.2902	1.6606	1.9845	2.3650	2.6269
99	0.6770	1.2902	1.6604	1.9842	2.3646	2.6264
100	0.6770	1.2901	1.6602	1.9840	2.3642	2.6259
110	0.6769	1.2899	1.6598	1.9838	2.3637	2.6253
120	0.6768	1.2896	1.6597	1.9836	2.3633	2.6248
∞	0.6768	1.2895	1.6595	1.9833	2.3629	2.6243

TABLE E.5

Critical Values of F

For a particular combination of numerator and denominator degrees of freedom, entry represents the critical values of F corresponding to the cumulative probability $(1 - \alpha)$ and a specified upper-tail area (α) .



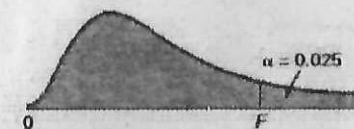
Cumulative Probabilities = 0.95																				
		Numerator, df_1																		
Denominator, df_2		1	2	3	4	5	6	7	8	9	10	12	15	20	24	30	40	60	120	∞
1		161.40	199.50	215.70	224.60	230.20	234.00	236.80	238.90	240.50	241.90	243.30	245.00	248.00	249.10	250.10	251.10	252.20	253.30	254.30
2		18.51	19.00	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	2.11	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	1.91	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
∞		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

(continued)

TABLE E.5

Critical Values of F (continued)

For a particular combination of numerator and denominator degrees of freedom, entry represents the critical values of F corresponding to the cumulative probability $(1 - \alpha)$ and a specified upper-tail area (α).

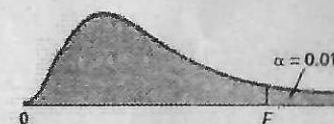


Cumulative Probability = 0.975																				
Upper Tail Area = 0.025																				
Denominator, df_2	Numerator, df_1																			
	1	2	3	4	5	6	7	8	9	10	12	15	20	24	30	40	60	120	∞	
1	647.80	799.50	864.20	899.60	921.80	937.10	948.20	956.70	963.30	968.60	976.70	984.90	993.10	997.20	1,001.00	1,006.00	1,010.00	1,014.00	1,018.00	
2	38.51	39.00	39.17	39.25	39.30	39.33	39.36	39.39	39.40	39.41	39.43	39.45	39.46	39.46	39.46	39.47	39.48	39.49	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	
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	
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	8.81	7.28	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	
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	
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	
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	
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	
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	
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	
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	
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	
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	
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	
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	
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	
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	
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	2.23	2.16	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	
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	
23	5.75	4.35	3.75	3.41	3.18	3.02	2.90	2.80	2.73	2.67	2.57	2.47	2.36	2.30	2.24	2.18	2.11	2.04	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	
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	
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	
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	
28	5.61	4.23	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	
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	
30	5.57	4.18	3.59	3.25	3.02	2.86	2.74	2.65	2.57	2.51	2.41	2.30	2.19	2.13	2.07	2.01	1.94	1.87	1.79	
40	5.42	4.03	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	
60	5.29	3.91	3.34	3.01	2.78	2.62	2.50	2.41	2.33	2.27	2.17	2.06	1.95	1.89	1.82	1.75	1.67	1.58	1.48	
120	5.15	3.80	3.23	2.89	2.67	2.50	2.38	2.29	2.21	2.15	2.05	1.94	1.83	1.77	1.70	1.63	1.53	1.43	1.31	
∞	5.02	3.69	3.12	2.79	2.57	2.41	2.29	2.19	2.11	2.05	1.95	1.84	1.73	1.67	1.60	1.52	1.42	1.32	1.00	

TABLE E.5

Critical Values of F (continued)

For a particular combination of numerator and denominator degrees of freedom, entry represents the critical values of F corresponding to the cumulative probability $(1 - \alpha)$ and a specified upper-tail area (α) .



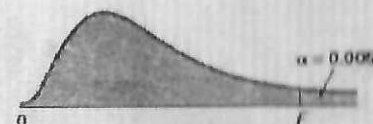
Cumulative Probabilities = 0.99																				
Upper-Tail Area = 0.01																				
Denominator, d_2	Numerator, d_1																			
	1	2	3	4	5	6	7	8	9	10	12	15	20	24	30	40	60	120	∞	
1	4,052.00	4,999.50	5,403.00	5,625.00	5,764.00	5,859.00	5,928.00	5,982.00	6,022.00	6,056.00	6,106.00	6,157.00	6,209.00	6,235.00	6,261.00	6,287.00	6,313.00	6,339.00	6,366.00	
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	2.66	
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	
∞	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	

(continued)

TABLE E.5

Critical Values of F (continued)

For a particular combination of numerator and denominator degrees of freedom, entry represents the critical values of F corresponding to the cumulative probability $(1 - \alpha)$ and a specified upper-tail area (α).



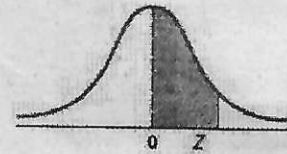
Cumulative Probabilities = 0.995																				
Upper - Tail Area = 0.005																				
Numerator, df_1																				
Denominator, df_2	1	2	3	4	5	6	7	8	9	10	12	15	20	24	30	40	60	120	∞	
1	16,211.00	20,000.00	21,615.00	22,500.00	23,056.00	23,437.00	23,715.00	23,925.00	24,091.00	24,224.00	24,426.00	24,630.00	24,836.00	24,910.00	25,044.00	25,148.00	25,253.00	25,359.00	25,465.00	
2	198.50	199.00	199.20	199.20	199.30	199.30	199.40	199.40	199.40	199.40	199.40	199.40	199.40	199.40	199.40	199.40	199.40	199.40	199.40	
3	55.55	49.80	47.47	46.19	45.39	44.84	44.43	44.13	43.88	43.69	43.59	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	20.44	20.17	20.00	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	13.15	12.90	12.78	12.66	12.53	12.40	12.27	12.11	
6	18.63	14.54	12.92	12.03	11.46	11.07	10.79	10.57	10.39	10.25	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	7.97	7.75	7.63	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	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	6.03	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	5.47	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	5.05	4.86	4.75	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	4.72	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	4.46	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	4.25	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	4.07	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	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	3.79	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	3.68	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	3.59	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	3.50	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	4.02	3.89	3.77	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	3.36	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	3.30	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	3.25	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	3.20	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	3.15	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	3.11	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	3.07	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	3.21	3.04	2.86	2.76	2.66	2.56	2.45	2.33	2.21	
30	9.18	6.35	5.24	4.62	4.23	3.95	3.74	3.58	3.45	3.34	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	2.78	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	2.57	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	2.37	2.19	2.09	1.98	1.87	1.75	1.61	1.43	
∞	7.88	5.30	4.28	3.72	3.35	3.09	2.90	2.74	2.62	2.52	2.36	2.19	2.00	1.90	1.79	1.67	1.53	1.36	1.00	

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TABLE E.10

The Standardized Normal Distribution

Entry represents area under the standardized normal distribution from the mean to Z



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	.2518	.2549
0.7	.2580	.2612	.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	.4986	.4986	.4987	.4987	.4988	.4988	.4989	.4989	.4989	.4990
3.1	.4990	.4990	.4991	.4991	.4991	.4991	.4992	.4992	.4992	.4992
3.2	.4993	.4993	.4993	.4993	.4994	.4994	.4994	.4994	.4994	.4995
3.3	.4995	.4995	.4995	.4995	.4995	.4995	.4996	.4996	.4996	.4996
3.4	.4996	.4996	.4996	.4997	.4997	.4997	.4997	.4997	.4997	.4997
3.5	.4997	.4997	.4997	.4997	.4998	.4998	.4998	.4998	.4998	.4998
3.6	.4998	.4998	.4998	.4998	.4998	.4998	.4998	.4998	.4998	.4998
3.7	.4998	.4999	.4999	.4999	.4999	.4999	.4999	.4999	.4999	.4999
3.8	.4999	.4999	.4999	.4999	.4999	.4999	.4999	.4999	.4999	.4999
3.9	.4999	.4999	.4999	.4999	.4999	.4999	.4999	.4999	.4999	.4999