Lib 8/05/19 Morning

[This question paper contains 24 printed pages]

**Your Roll No.** : .....

**Sl. No. of Q. Paper** : **8625** **IC**

Unique Paper Code : 12273402

Name of the Course : **B.A. (Hons.) Economics - CBCS - SEC**

Name of the Paper : Data Analysis

Semester : IV

***Time : 3 Hours*** ***Maximum Marks : 75***

**Instructions for Candidates :**

परीक्षार्थियों के लिए निर्देश :

(a) Write your Roll No. on the top immediately on receipt of this question paper.

इस प्रश्न-पत्र के प्राप्त होने पर तुरंत शीर्ष पर अपना रोल नंबर लिखें।

(b) Answer may be written either in **English** or in **Hindi**; but the same medium should be used throughout the paper.

इस प्रश्न-पत्र का उत्तर **अंग्रेजी** या **हिंदी** किसी एक भाषा में दीजिए, लेकिन सभी उत्तर एक ही भाषा में होने चाहिए।

(c) The paper is divided into **five** Sections. Choice is applicable for **Sections- I, II,** and **IV** only.

यह प्रश्न-पत्र **पाँच** खण्डों में विभाजित है। केवल **खण्ड - I, II,** तथा **IV** के लिए चयन उपलब्ध हैं।

P.T.O.

(d) Attempt **all** Sections. Answer to all questions within each section are to follow together.

**सभी** खण्डों से उत्तर देना हैं। प्रत्येक खण्ड के सभी प्रश्नों को एक साथ करिए।

(e) Use of simple calculators is allowed.

सामान्य कैल्कुलेटर का उपयोग किया जा सकता हैं।

## Section - I

## खण्ड - I

**Note :** Attempt any **one** from questions **1** and **2** :

प्रश्न संख्या **1** तथा **2** में से किन्हीं एक का उत्तर दें :

**1.** (a) For a distribution, the mean is 5, variance is 2, $\beta_1 = +1$, $\beta_2 = 4$. Obtain the first four moments about the origin. Comment upon the nature of distribution. 6

एक वितरण के लिए माध्य = 5, प्रसरण = 2, $\beta_1 = +1$ तथा $\beta_2 = 4$. शून्य से लगभग प्रथम चार आघूर्ण ज्ञात करें। वितरण की प्रकृति पर टिप्पणी करें।

(b) Karl Pearson's coefficient of skewness of a distribution is 0.5. The median and mode of the distribution are respectively, 42 and 32. Find : (i) the mean, (ii) the standard deviation and (iii) the coefficient of variation. 4

एक वितरण के विषमता के कार्ल पियर्सन के गुणांक 0.5 हैं। वितरण के मध्यिका एवं बहुलक क्रमश: 42 एवं 32 हैं। (i) माध्य (ii) प्रमाप विचलन तथा (iii) प्रसरण का गुणांक ज्ञात करें।





**2.** (a) The following table shows the earnings of 100 students in their summer jobs :

100 छात्रों के उनके ग्रीष्मकालीन नौकरी में आय को निम्न टेबल द्वारा दिखाया गया है :

| **Earnings (₹)** आय (₹) | **Number of Students** विद्यार्थियों की संख्या |
|---|---|
| 0-500 | 12 |
| 500-1000 | 19 |
| 1000-1500 | 26 |
| 1500-2000 | 21 |
| 2000-2500 | 13 |
| 2500-3000 | 7 |
| 3000-3500 | 2 |

(i) Calculate the arithmetic mean and mode of the above distribution.

उपरोक्त वितरण के अंकगणितीय माध्य एवं बहुलक की गणना करें।

(ii) Using the results of (i) comment on the symmetry of the distribution. Give reasons for your answer. 6

उपरोक्त परिणाम का उपयोग (i) वितरण के सम्मितता पर टिप्पणी करें। अपना उत्तर कारण सहित दें।

(b) For a mesokurtic distribution, the first moment about 7 is 23 and the second moment about origin is 1000. Find the coefficient of variation and the fourth moment about the mean. 4

मध्य शीर्षक वितरण के लिए, 7 से प्रथम आघूर्ण 23 हैं तथा शून्य से दूसरा आघूर्ण 1000 हैं। माध्य से चौथा आघूर्ण तथा प्रसरण का गुणांक ज्ञात करें।

## Section - II

## खण्ड - II

**Note :** Question No. **3** is compulsory. Attempt any **one** question from **4** and **5**.

प्रश्न संख्या **3** अनिवार्य है। प्रश्न **4** एवं **5** में से किन्हीं **एक** का उत्तर दें।

**3.** A random variable X has the following probability distribution :

एक दैव चर X का प्रायिकता वितरण निम्नलिखित है :

| X : | -1 | 0 | 1 | 2 |
|---|---|---|---|---|
| P(X=x) : | 1/3 | 1/6 | 1/6 | 1/3 |

Find : (i) E (X) (ii) E(X+2) (iii) Var (2X) 5

ज्ञात करें :





**4.** (a) (i) Explain briefly the properties of normal distribution.

सामान्य वितरण के विशेषताओं का संक्षेप में विवेचन करें।

(ii) On a economics examination, grades are normally distributed with mean grade being 72 and standard deviation was 9. The top 10% of the students are to receive A grade. What is the minimum grade a student must get in order to receive an A grade ? 5

अर्थशास्त्र परीक्षा में, ग्रेड को माध्य श्रेणी 72 तथा प्रमाप विचलन 9 के साथ सामान्य रूप से वितरित किया जाता है। छात्रों के शीर्ष 10 प्रतिशत A श्रेणी प्राप्त करने को है। न्यूनतम श्रेणी क्या है जिसे एक छात्र को A श्रेणी को प्राप्त करने के लिए अवश्य प्राप्त करना चाहिए ?

(b) In an examination 30% of the students failed in statistics, 25% in mathematics and 12% in both subjects. A student is selected at random. Find the probability that : 3

एक परीक्षा में 30 प्रतिशत छात्र सांख्यिकी में, 25 प्रतिशत गणित में तथा 12 प्रतिशत दोनों विषय में असफल हुए। एक छात्र को दैव रूप से चुना जाता है। प्रायिकता ज्ञात करें जब :

(i) a student has failed in statistics if it is known that he has failed in mathematics.

एक छात्र सांख्यिकी में असफल हुआ यद्यपि यह जाना जाता है कि वह गणित में असफल हुआ है।

(ii) a student has failed in at least one of the subjects.

एक छात्र कम से कम एक विषय में असफल हुआ है।

(iii) a student has passed in at least one of the subjects.

एक छात्र कम से कम एक विषय में सफल हुआ है।

(c) The average number of defective pieces in the manufacturing of an article, is 1 in 10. Find the probability of getting exactly 3 defective articles in a packet of 10 articles selected at random. 2

एक सामान के उत्पादन में खराब अंश का औसत संख्या 10 में से 1 है। दैव रूप से चुने गये 10 सामानों के पैकेट में वास्तविक रूप से 3 खराब सामान के प्राप्त होने के प्रायिकता ज्ञात करें।

5. (a) Two firms A and B consider bidding on a road building job, which may or may not be awarded depending on the amounts of the bids. Firm A submits a bid and the probability is 3/4 that it will get the job provided firm B does not bid. The probability is 3/4 that firm B will bid and if it does, the probability that firm A gets the job is only 1/3. 4

एक सड़क बनाने के काम पर दो फर्म A तथा B नीलामी पर विचार करते हैं, जिसे नीलामी के रकम के आधार पर प्रदान किया जा सकता है या नहीं भी | फर्म A एक नीलामी पेश करता है और प्रायिकता 3/4 है जबकि फर्म B नीलामी नहीं लगायेगा। यदि फर्म B के नीलामी करने की प्रायिकता 3/4 है, तो फर्म A के काम पाने की प्रायिकता 1/3 हो जाती है ।

(i) What is the probability that firm A gets the job ?

प्रायिकता क्या है कि फर्म A काम पाता है ?





(ii) If firm A gets the job, what is the probability that firm B did not bid ?

यदि फर्म A काम पाता है तो प्रायिकता क्या होगी कि फर्म B ने नीलामी नहीं लगाया है ?

(b) A student Union Leader believes that 30% of all students will strongly support his demand for a tennis court in the college. He approaches 5 students at random to ask their opinion. What is the probability that majority of these students will strongly support his demand ? 3

एक छात्र संगठन का नेता विश्वास करते हैं कि कॉलेज में टेनिस कोर्ट के लिए कुल छात्रों का 30% अपने माँग का मजबूती से समर्थन देंगे। वे उनके मत को पूछने के लिए दैव रूप में 5 छात्रों के पास जाते हैं। प्रायिकता क्या है कि इन छात्रों के बहुमत संख्या उनके माँग का मजबूती से समर्थन करेंगे।

(c) In a bolt factory, machines A, B and C manufacture respectively, 25%, 35% and 40% of the total output. Of their output, respectively 5%, 4% and 2% are known to be defective. A bolt is picked up at random and is found to be defective. Find the probability that it was produced by machine B or C. 3

एक बोल्ट फैक्टरी में मशीन A, B तथा C कुल उत्पादन का क्रमश: 25%, 35% एवं 40% उत्पादन करते हैं। उनके कुल उत्पादन में क्रमश: 5%, 4% तथा 2% खराब होने को जाना जाता है। एक बोल्ट को दैव रूप से चुना जाता है तथा खराब पाया जाता है। प्रायिकता ज्ञात करें कि यह मशीन B या C द्वारा उत्पादित किया गया था।

## Section - III

## खण्ड - III

**Note : All** questions are compulsory.

सभी प्रश्न अनिवार्य हैं।

**6.** Define an unbiased estimator. If $X_1$ , $X_2$, $X_3$ constitute a random sample of size 3 from a normal population with mean $\mu$ and standard deviation $\sigma$. Consider the following estimators of the population mean for unbiasedness and compare their variance :

$A = 5X_1+2X_2+3X_3/ 10;$

$B = X_1 +2X_2+3X_3/10$ and

$C = X_1 +X_2+X_3/3$

Which of the three would you prefer and why ? 5

निष्पक्ष प्राचाल को परिभाषित करें। यदि $X_1$ , $X_2$, $X_3$ एक सामान्य समग्र से प्रमाप विचलन $\sigma$ तथा माध्य $\mu$ के साथ 3 आकार के एक दैव नमूना को दर्शाता है । निष्पक्षता के लिए समग्र मध्य के निम्नलिखित प्राचाल पर विचार करें तथा उनके प्रसरण से तुलना करें :

$A = 5X_1+2X_2+3X_3/ 10;$

$B = X_1 +2X_2+3X_3/10$ और

$C = X_1 +X_2+X_3/3$

तीनों में से किसे आप वरीयता देंगे तथा क्यों ?





**7.** (a) A paint manufacturer wants to determine the average drying time of a new interior wall paint whose drying time follows a normal distribution with mean $\mu$ and standard deviation $\sigma$ . For 12 test areas of equal size he obtained mean drying time of 66.3 minutes with standard deviation of 8.4 minutes.

एक पेन्ट उत्पादक एक नई अन्त: दीवाल पेन्ट के औसत सूखने का समय निर्धारण करना चाहता है जिसका सूखने का समय सामान्य वितरण के माध्य $\mu$ तथा प्रमाप विचलन $\sigma$ का अनुसरण करता है। सामान आकार के 12 जाँच क्षेत्रों के लिए वह 8.4 मिनट के प्रमाप विचलन के साथ 66.3 मिनट के औसत सूखना समय को प्राप्त किया।

(i) Construct 95% confidence interval for the true mean $\mu$.

सत्य माध्य $\mu$ के लिए 95% विश्वास अंतराल को बनाइये।

(ii) Would a 90% confidence interval calculated from this same sample have been narrower or wider than the given interval ? Explain the reasoning.

क्या इस सामान नमूना से गणना किया गया 90% विश्वास अंतराल दिये गये अंतराल से संकुचित या विस्तारित रहा है। तार्किक रूप से समझाइए।

(iii) Consider the following statement :

निम्न कथन पर विचार करें :

"The calculated interval implies that the true population mean $\mu$ lies in it with probability 95%." Is this statement correct ? Why or why not ? 6

"गणना किए गये अंतराल से अभिप्राय है कि सत्य समग्र माध्य $\mu$ अपने 95% प्रायिकता के साथ अंदर पड़ता है। " क्या यह कथन सत्य है ? क्यों या क्यों नहीं ?

(b) In order to estimate the average landholding of a rural household in a district, a random sample of 400 families is taken. If the household landholding is known to have a standard deviation of 3 acres, and mean landholding obtained from the sample is 6 acres, calculate the 95% confidence interval for the mean landholding of all the households in the district. 4

एक जिला में एक ग्रामीण गृहस्वामी के औसत भूमिधारण को आकलन के क्रम में 400 परिवारों के दैव नमूना लिया जाता है। यदि गृहस्वामी भूमिधारण को 3 एकड़ के प्रमाप विचलन तथा 6 एकड़ के माध्य के रूप में जाना जाता है, तो जिला में इस नमूना से प्राप्त औसत भूमिधारण के लिए 95% विश्वास अंतराल की गणना करें।





## Section - IV
## खण्ड - IV

**Note :** Question No. **8** is compulsory. Attempt any **one** question from **9** and **10**.

प्रश्न संख्या **8** अनिवार्य है। प्रश्न **9** तथा **10** में से कोई एक प्रश्न का उत्तर दें।

8. Calculate the values of $Y = (X - 4)^3$ corresponding to values of $X$ = 1,2,3,4 and 5 and obtain the coefficient of correlation between $X$ and $Y$. Is the coefficient of correlation unity ? Why or why not ? 5

$X$ = 1,2,3,4 तथा 5 के मूल्यों से संबन्धित $Y = (X - 4)^3$ के मूल्यों की गणना करें तथा $X$ तथा $Y$ के बीच सहसंबंध के गुणांक की गणना करें। क्या सहसंबंध का गुणांक इकाई है ? क्यों या क्यों नहीं।

9. The following table gives the information on years of education ($X$) of farmers and annual yields per acre ($Y$) on their farms :

निम्नलिखित टेबल किसान के शिक्षा का वर्ष (X) तथा उनके खेती पर प्रति एकड़ (Y) वार्षिक उपज की सूचना दी गई है :

| X | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 |
|---|---|---|---|---|---|---|---|---|---|
| Y | 4 | 4 | 6 | 10 | 10 | 8 | 12 | 8 | 6 |



P.T.O.

(i) Fit the regression equation of yield per acre (Y) on education (X) and give an economic interpretation to it. 5

प्रति एक उपज (Y) के शिक्षा (X) पर प्रतिपगमन समीकरण को स्थापित करें तथा इसके आर्थिक निहितार्थ को बताइये।

(ii) What is the magnitude of the 'Explained Variation' in the dependent variable ? Find the coefficient of correlation from it. 3

आश्रित चर में "व्यक्त विचरण" की मात्रा क्या है। इससे सहसंबंध के गुणांक को ज्ञात करें।

(iii) Predict the value of yield per acre (Y) when years of education (X) of the farmers are 9 years. 2

प्रति एक उपज (Y) का मूल्य अनुमानित करें जब किसानों की शिक्षा (X) के वर्ष 9 हैं।

**10.** (a) A regression equation Y on X for 10 pairs of values of the variables provides the value of the coefficient of correlation as – 0.8. If the variance of Y is 25, calculate : 3

चरों के मूल्यों के 10 जोड़ों के लिए Y पर X का प्रतिपगमन समीकरण सहसंबंध के गुणांक का मूल्य –0.8 देता है यदि Y का प्रसरण 25 है तो गणना करें कि :

(i) the proportion of the total variation in Y that is explained by the regression.

Y में कुल विचरण का अनुपात प्रतिपगमन द्वारा व्यक्त किया जाता है।





(ii) the total unexplained variation

कुल अव्यक्त विचरण

(iii) standard error of the regression

प्रतिपगमन का प्रमाप विभ्रम

(b) For a given set of bivariate data, the following results were obtained :

द्विगामी आँकडा का समूह दिया हुआ होने के लिए निम्न परिणाम प्राप्त किया गया :

$N = 100$, $\sum X = 5000$, $\sum Y = 10{,}000$, $\sum X^2 = 2{,}60{,}000$, $\sum Y^2 = 10{,}40{,}000$, $\sum XY = 5{,}16{,}000$ .

(i) Find the predicted value of Y when X = 60

Y के अनुमानित मूल्य ज्ञात करें जब X =60

(ii) Calculate the coefficient of correlation between X and Y.

X तथा Y के बीच सहसंबंध गुणांक की गणना करें।

(iii) What is standard error of estimate in the regression of Y on X ? 7

Y पर X के प्रतिपगमन में आकलन के प्रमाप विभ्रम क्या हैं ?

## Section - V
## खण्ड - V

**Note : All** questions are compulsory.

**सभी** प्रश्न अनिवार्य हैं।

**11.** (a) Using the following data , calculate Marshall-Edgeworth and Laspeyre's price index. 4

निम्न आँकड़ों का उपयोग करते हुए, मार्शल-एजवर्थ तथा लॉस्पेयर कीमत सूचकांक की गणना करें ।

| | Base Year आधार वर्ष | | Current Year वर्तमान वर्ष | |
|---|---|---|---|---|
| Commodity वस्तु /जिंस | Expenditure खर्च | Quantity मात्रा | Expenditure खर्च | Price मूल्य |
| A | 360 | 12 | 200 | 20 |
| B | 64 | 16 | 36 | 4 |
| C | 575 | 23 | 238 | 14 |

(b) Using the following data calculate Fisher's Ideal index and verify that it satisfies both Time Reversal Test and Factor Reversal Test : 6





निम्न आंकड़ों का उपयोग करते हुए ,फिशर के आदर्श सूचकांक की गणना करें तथा सत्यापित करें कि यह दोनों समय व्युत्क्रमता जाँच तथा तत्व व्युत्क्रमता जाँच को संतुष्ट करता है ।

| Commodity वस्तु/जिंस | Base Year आधार वर्ष | | Current Year वर्तमान वर्ष | |
|---|---|---|---|---|
| | Price मूल्य | Quantity मात्रा | Price मूल्य | Quantity मात्रा |
| A | 6 | 50 | 10 | 60 |
| B | 2 | 100 | 2 | 120 |
| C | 4 | 60 | 6 | 60 |

**12.** (a) A department store sells personal computers, laptops and Ipad. The percentage distribution of the total sales volume (in rupees) is estimated as 30% personal computers, 50% laptops and 20% Ipad. The prices of personal computers, laptops and Ipad in 2010 were ₹ 20,000, ₹15,000 and ₹5,000 per unit respectively while their prices in 2015 were ₹25,000, ₹25,000 and ₹ 8,000 . A weighted price index for 2015 with base 2010 is to be computed. 6

एक विभागीय भंडार व्यक्तिगत कम्प्यूटर , लैपटाप तथा I-पैड बेचता है। कुल बिक्री मात्रा (₹ में) के प्रतिशत वितरण को 30% व्यक्तिगत कम्प्यूटर ,50% लैपटाप तथा 20% I-पैड के रूप में आकलित किया जाता है । 2010 में व्यक्तिगत कम्प्यूटर , लैपटाप तथा I-पैड की कीमते क्रमशः 20,000 ₹,15,000 ₹ तथा 5,000 ₹ प्रति इकाई थी जबकि 2015 में कीमतें 25000₹ , 25,000₹ तथा 8,000₹ थी । 2010 के आधार के साथ 2015 के लिए भारित कीमत सूचकांक को आकलित कीजिये ।

(i) Which index number formula is appropriate and why ?

कौन –सा सूचकांक नंबर सूत्र उचित है और क्यों ?

(ii) Compute the index

सूचकांक की गणना करें ।

(b) Show that if the prices of all the goods change in the same ratio, the Laspeyres's and Paasche's price index numbers become equal and the weighting system is irrelevant. 4

दिखाएँ कि यदि सभी वस्तुओं की कीमतें समान अनुपात में परिवर्तित होती हैं तो लॉस्पेयर तथा पाश्चे की कीमत सूचकांक संख्या समान होगी तथा भारित व्यवस्था अप्रासंगिक है ।







**Table A.1 Cumulative Binomial Probabilities**

$B(x; n, p) = \sum_{i=0}^{x} b(i; n, p)$

a. $n = 5$

| | | p | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0.01 | 0.05 | 0.10 | 0.20 | 0.25 | 0.30 | 0.40 | 0.50 | 0.60 | 0.70 | 0.75 | 0.80 | 0.90 | 0.95 | 0.99 |
| | 0 | .951 | .774 | .590 | .328 | .237 | .168 | .078 | .031 | .010 | .002 | .001 | .000 | .000 | .000 | .000 |
| | 1 | .999 | .977 | .919 | .737 | .633 | .528 | .337 | .188 | .087 | .031 | .016 | .007 | .000 | .000 | .000 |
| x | 2 | 1.000 | .999 | .991 | .942 | .896 | .837 | .683 | .500 | .317 | .163 | .104 | .058 | .009 | .001 | .000 |
| | 3 | 1.000 | 1.000 | 1.000 | .993 | .984 | .969 | .913 | .812 | .663 | .472 | .367 | .263 | .081 | .023 | .001 |
| | 4 | 1.000 | 1.000 | 1.000 | 1.000 | .999 | .998 | .990 | .969 | .922 | .832 | .763 | .672 | .410 | .226 | .049 |

b. $n = 10$

| | | p | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0.01 | 0.05 | 0.10 | 0.20 | 0.25 | 0.30 | 0.40 | 0.50 | 0.60 | 0.70 | 0.75 | 0.80 | 0.90 | 0.95 | 0.99 |
| | 0 | .904 | .599 | .349 | .107 | .056 | .028 | .006 | .001 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| | 1 | .996 | .914 | .736 | .376 | .244 | .149 | .046 | .011 | .002 | .000 | .000 | .000 | .000 | .000 | .000 |
| | 2 | 1.000 | .988 | .930 | .678 | .526 | .383 | .167 | .055 | .012 | .002 | .000 | .000 | .000 | .000 | .000 |
| | 3 | 1.000 | .999 | .987 | .879 | .776 | .650 | .382 | .172 | .055 | .011 | .004 | .001 | .000 | .000 | .000 |
| | 4 | 1.000 | 1.000 | .998 | .967 | .922 | .850 | .633 | .377 | .166 | .047 | .020 | .006 | .000 | .000 | .000 |
| x | 5 | 1.000 | 1.000 | 1.000 | .994 | .980 | .953 | .834 | .623 | .367 | .150 | .078 | .033 | .002 | .000 | .000 |
| | 6 | 1.000 | 1.000 | 1.000 | .999 | .996 | .989 | .945 | .828 | .618 | .350 | .224 | .121 | .013 | .001 | .000 |
| | 7 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | .998 | .988 | .945 | .833 | .617 | .474 | .322 | .070 | .012 | .000 |
| | 8 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | .998 | .989 | .954 | .851 | .756 | .624 | .264 | .086 | .004 |
| | 9 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | .999 | .994 | .972 | .944 | .893 | .651 | .401 | .096 |

c. $n = 15$

| | | p | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0.01 | 0.05 | 0.10 | 0.20 | 0.25 | 0.30 | 0.40 | 0.50 | 0.60 | 0.70 | 0.75 | 0.80 | 0.90 | 0.95 | 0.99 |
| | 0 | .860 | .463 | .206 | .035 | .013 | .005 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| | 1 | .990 | .829 | .549 | .167 | .080 | .035 | .005 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| | 2 | 1.000 | .964 | .816 | .398 | .236 | .127 | .027 | .004 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| | 3 | 1.000 | .995 | .944 | .648 | .461 | .297 | .091 | .018 | .002 | .000 | .000 | .000 | .000 | .000 | .000 |
| | 4 | 1.000 | .999 | .987 | .836 | .686 | .515 | .217 | .059 | .009 | .001 | .000 | .000 | .000 | .000 | .000 |
| | 5 | 1.000 | 1.000 | .998 | .939 | .852 | .722 | .403 | .151 | .034 | .004 | .001 | .000 | .000 | .000 | .000 |
| | 6 | 1.000 | 1.000 | 1.000 | .982 | .943 | .869 | .610 | .304 | .095 | .015 | .004 | .001 | .000 | .000 | .000 |
| | 7 | 1.000 | 1.000 | 1.000 | .996 | .983 | .950 | .787 | .500 | .213 | .050 | .017 | .004 | .000 | .000 | .000 |
| | 8 | 1.000 | 1.000 | 1.000 | .999 | .996 | .985 | .905 | .696 | .390 | .131 | .057 | .018 | .000 | .000 | .000 |
| | 9 | 1.000 | 1.000 | 1.000 | 1.000 | .999 | .996 | .966 | .849 | .597 | .278 | .148 | .061 | .002 | .000 | .000 |
| | 10 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | .999 | .991 | .941 | .783 | .485 | .314 | .164 | .013 | .001 | .000 |
| | 11 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | .998 | .982 | .909 | .703 | .539 | .352 | .056 | .005 | .000 |
| | 12 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | .996 | .973 | .873 | .764 | .602 | .184 | .036 | .000 |
| | 13 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | .995 | .965 | .920 | .833 | .451 | .171 | .010 |
| | 14 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | .995 | .987 | .965 | .794 | .537 | .140 |

(continued)

## Table A.1 Cumulative Binomial Probabilities (cont.)

$$B(x; n, p) = \sum_{y=0}^{x} b(y; n, p)$$

d. $n = 20$

| | p | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| x | 0.01 | 0.05 | 0.10 | 0.20 | 0.25 | 0.30 | 0.40 | 0.50 | 0.60 | 0.70 | 0.75 | 0.80 | 0.90 | 0.95 | 0.99 |
| 0 | .818 | .358 | .122 | .012 | .003 | .001 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| 1 | .983 | .736 | .392 | .069 | .024 | .008 | .001 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| 2 | .999 | .925 | .677 | .206 | .091 | .035 | .004 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| 3 | 1.000 | .984 | .867 | .411 | .225 | .107 | .016 | .001 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| 4 | 1.000 | .997 | .957 | .630 | .415 | .238 | .051 | .006 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| 5 | 1.000 | 1.000 | .989 | .804 | .617 | .416 | .126 | .021 | .002 | .000 | .000 | .000 | .000 | .000 | .000 |
| 6 | 1.000 | 1.000 | .998 | .913 | .786 | .608 | .250 | .058 | .006 | .000 | .000 | .000 | .000 | .000 | .000 |
| 7 | 1.000 | 1.000 | 1.000 | .968 | .898 | .772 | .416 | .132 | .021 | .001 | .000 | .000 | .000 | .000 | .000 |
| 8 | 1.000 | 1.000 | 1.000 | .990 | .959 | .887 | .596 | .252 | .057 | .005 | .001 | .000 | .000 | .000 | .000 |
| 9 | 1.000 | 1.000 | 1.000 | .997 | .986 | .952 | .755 | .412 | .128 | .017 | .004 | .001 | .000 | .000 | .000 |
| 10 | 1.000 | 1.000 | 1.000 | .999 | .996 | .983 | .872 | .588 | .245 | .048 | .014 | .003 | .000 | .000 | .000 |
| 11 | 1.000 | 1.000 | 1.000 | 1.000 | .999 | .995 | .943 | .748 | .404 | .113 | .041 | .010 | .000 | .000 | .000 |
| 12 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | .999 | .979 | .868 | .584 | .228 | .102 | .032 | .000 | .000 | .000 |
| 13 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | .994 | .942 | .750 | .392 | .214 | .087 | .002 | .000 | .000 |
| 14 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | .998 | .979 | .874 | .584 | .383 | .196 | .011 | .000 | .000 |
| 15 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | .994 | .949 | .762 | .585 | .370 | .043 | .003 | .000 |
| 16 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | .999 | .984 | .893 | .775 | .589 | .133 | .016 | .000 |
| 17 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | .996 | .965 | .909 | .794 | .323 | .075 | .001 |
| 18 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | .999 | .992 | .976 | .931 | .608 | .264 | .017 |
| 19 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | .999 | .997 | .988 | .878 | .642 | .182 |

(continued)





## Table A.2 Cumulative Poisson Probabilities (cont.)

$$P(x; \mu) = \sum_{y=0}^{x} \frac{e^{-\mu} \mu^{y}}{y!}$$

| | μ | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| x | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 | 7.0 | 8.0 | 9.0 | 10.0 | 15.0 | 20.0 |
| 0 | .135 | .050 | .018 | .007 | .002 | .001 | .000 | .000 | .000 | .000 | .000 |
| 1 | .406 | .199 | .092 | .040 | .017 | .007 | .003 | .001 | .000 | .000 | .000 |
| 2 | .677 | .423 | .238 | .125 | .062 | .030 | .014 | .006 | .003 | .000 | .000 |
| 3 | .857 | .647 | .433 | .265 | .151 | .082 | .042 | .021 | .010 | .000 | .000 |
| 4 | .947 | .815 | .629 | .440 | .285 | .173 | .100 | .055 | .029 | .001 | .000 |
| 5 | .983 | .916 | .785 | .616 | .446 | .301 | .191 | .116 | .067 | .003 | .000 |
| 6 | .995 | .966 | .889 | .762 | .606 | .450 | .313 | .207 | .130 | .008 | .000 |
| 7 | .999 | .988 | .949 | .867 | .744 | .599 | .453 | .324 | .220 | .018 | .001 |
| 8 | 1.000 | .996 | .979 | .932 | .847 | .729 | .593 | .456 | .333 | .037 | .002 |
| 9 | | .999 | .992 | .968 | .916 | .830 | .717 | .587 | .458 | .070 | .005 |
| 10 | | 1.000 | .997 | .986 | .957 | .901 | .816 | .706 | .583 | .118 | .011 |
| 11 | | | .999 | .995 | .980 | .947 | .888 | .803 | .697 | .185 | .021 |
| 12 | | | 1.000 | .998 | .991 | .973 | .936 | .876 | .792 | .268 | .039 |
| 13 | | | | .999 | .996 | .987 | .966 | .926 | .864 | .363 | .066 |
| 14 | | | | 1.000 | .999 | .994 | .983 | .959 | .917 | .466 | .105 |
| 15 | | | | | .999 | .998 | .992 | .978 | .951 | .568 | .157 |
| 16 | | | | | 1.000 | .999 | .996 | .989 | .973 | .664 | .221 |
| 17 | | | | | | 1.000 | .998 | .995 | .986 | .749 | .297 |
| 18 | | | | | | | .999 | .998 | .993 | .819 | .381 |
| 19 | | | | | | | 1.000 | .999 | .997 | .875 | .470 |
| 20 | | | | | | | | 1.000 | .998 | .917 | .559 |
| 21 | | | | | | | | | .999 | .947 | .644 |
| 22 | | | | | | | | | 1.000 | .967 | .721 |
| 23 | | | | | | | | | | .981 | .787 |
| 24 | | | | | | | | | | .989 | .843 |
| 25 | | | | | | | | | | .994 | .888 |
| 26 | | | | | | | | | | .997 | .922 |
| 27 | | | | | | | | | | .998 | .948 |
| 28 | | | | | | | | | | .999 | .966 |
| 29 | | | | | | | | | | 1.000 | .978 |
| 30 | | | | | | | | | | | .987 |
| 31 | | | | | | | | | | | .992 |
| 32 | | | | | | | | | | | .995 |
| 33 | | | | | | | | | | | .997 |
| 34 | | | | | | | | | | | .999 |
| 35 | | | | | | | | | | | .999 |
| 36 | | | | | | | | | | | 1.000 |

Table A.1 Cumulative Binomial Probabilities (cont.)

$$B(x; n, p) = \sum_{y=0}^{x} b(y; n, p)$$

$n = 25$

| | p | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.01 | 0.05 | 0.10 | 0.20 | 0.25 | 0.30 | 0.40 | 0.50 | 0.60 | 0.70 | 0.75 | 0.80 | 0.90 | 0.95 | 0.99 |
| 0 | .778 | .277 | .072 | .004 | .001 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| 1 | .974 | .642 | .271 | .027 | .007 | .002 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| 2 | .998 | .873 | .537 | .098 | .032 | .009 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| 3 | 1.000 | .966 | .764 | .234 | .096 | .033 | .002 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| 4 | 1.000 | .993 | .902 | .421 | .214 | .090 | .009 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| 5 | 1.000 | .999 | .967 | .617 | .378 | .193 | .029 | .002 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| 6 | 1.000 | 1.000 | .991 | .780 | .561 | .341 | .074 | .007 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| 7 | 1.000 | 1.000 | .998 | .891 | .727 | .512 | .154 | .022 | .001 | .000 | .000 | .000 | .000 | .000 | .000 |
| 8 | 1.000 | 1.000 | 1.000 | .953 | .851 | .677 | .274 | .054 | .004 | .000 | .000 | .000 | .000 | .000 | .000 |
| 9 | 1.000 | 1.000 | 1.000 | .983 | .929 | .811 | .425 | .115 | .013 | .000 | .000 | .000 | .000 | .000 | .000 |
| 10 | 1.000 | 1.000 | 1.000 | .994 | .970 | .902 | .586 | .212 | .034 | .002 | .000 | .000 | .000 | .000 | .000 |
| 11 | 1.000 | 1.000 | 1.000 | .998 | .980 | .956 | .732 | .345 | .078 | .006 | .001 | .000 | .000 | .000 | .000 |
| 12 | 1.000 | 1.000 | 1.000 | 1.000 | .997 | .983 | .846 | .500 | .154 | .017 | .003 | .000 | .000 | .000 | .000 |
| 13 | 1.000 | 1.000 | 1.000 | 1.000 | .999 | .994 | .922 | .655 | .268 | .044 | .020 | .002 | .000 | .000 | .000 |
| 14 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | .998 | .966 | .788 | .414 | .098 | .030 | .006 | .000 | .000 | .000 |
| 15 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | .987 | .885 | .575 | .189 | .071 | .017 | .000 | .000 | .000 |
| 16 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | .996 | .946 | .726 | .323 | .149 | .047 | .000 | .000 | .000 |
| 17 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | .999 | .978 | .846 | .488 | .273 | .109 | .002 | .000 | .000 |
| 18 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | .993 | .926 | .659 | .439 | .220 | .009 | .000 | .000 |
| 19 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | .998 | .971 | .807 | .622 | .383 | .033 | .001 | .000 |
| 20 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | .991 | .910 | .786 | .579 | .098 | .007 | .000 |
| 21 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | .998 | .967 | .904 | .766 | .236 | .034 | .000 |
| 22 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | .991 | .968 | .902 | .463 | .127 | .002 |
| 23 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | .998 | .993 | .973 | .729 | .358 | .026 |
| 24 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | .999 | .996 | .928 | .723 | .222 |

Table A.2 Cumulative Poisson Probabilities

$$F(x; \mu) = \sum_{y=0}^{x} \frac{e^{-\mu} \mu^y}{y!}$$

| | μ | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | .1 | .2 | .3 | .4 | .5 | .6 | .7 | .8 | .9 | 1.0 |
| 0 | .905 | .819 | .741 | .670 | .607 | .549 | .497 | .449 | .407 | .368 |
| 1 | .995 | .982 | .963 | .938 | .910 | .878 | .844 | .809 | .772 | .736 |
| 2 | 1.000 | .999 | .996 | .992 | .986 | .977 | .966 | .953 | .937 | .920 |
| 3 | | 1.000 | 1.000 | .999 | .998 | .997 | .994 | .991 | .987 | .981 |
| 4 | | | | 1.000 | 1.000 | 1.000 | .999 | .999 | .998 | .996 |
| 5 | | | | | | | 1.000 | 1.000 | 1.000 | .999 |
| 6 | | | | | | | | | | 1.000 |

(continued)

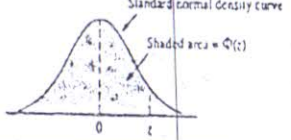






Table A.3 Standard Normal Curve Areas

$\Phi(z) = P(Z \le z)$




| z | .00 | .01 | .02 | .03 | .04 | .05 | .06 | .07 | .08 | .09 |
|---|---|---|---|---|---|---|---|---|---|---|
| −3.4 | .0003 | .0003 | .0003 | .0003 | .0003 | .0003 | .0003 | .0003 | .0003 | .0002 |
| −3.3 | .0005 | .0005 | .0005 | .0004 | .0004 | .0004 | .0004 | .0004 | .0004 | .0003 |
| −3.2 | .0007 | .0007 | .0006 | .0006 | .0006 | .0006 | .0006 | .0005 | .0005 | .0005 |
| −3.1 | .0010 | .0009 | .0009 | .0009 | .0008 | .0008 | .0008 | .0008 | .0007 | .0007 |
| −3.0 | .0013 | .0013 | .0013 | .0012 | .0012 | .0011 | .0011 | .0011 | .0010 | .0010 |
| −2.9 | .0019 | .0018 | .0017 | .0017 | .0016 | .0016 | .0015 | .0015 | .0014 | .0014 |
| −2.8 | .0026 | .0025 | .0024 | .0023 | .0023 | .0022 | .0021 | .0021 | .0020 | .0019 |
| −2.7 | .0035 | .0034 | .0033 | .0032 | .0031 | .0030 | .0029 | .0028 | .0027 | .0026 |
| −2.6 | .0047 | .0045 | .0044 | .0043 | .0041 | .0040 | .0039 | .0038 | .0037 | .0036 |
| −2.5 | .0062 | .0060 | .0059 | .0057 | .0055 | .0054 | .0052 | .0051 | .0049 | .0048 |
| −2.4 | .0082 | .0080 | .0078 | .0075 | .0073 | .0071 | .0069 | .0068 | .0066 | .0064 |
| −2.3 | .0107 | .0104 | .0102 | .0099 | .0096 | .0094 | .0091 | .0089 | .0087 | .0084 |
| −2.2 | .0139 | .0136 | .0132 | .0129 | .0125 | .0122 | .0119 | .0116 | .0113 | .0110 |
| −2.1 | .0179 | .0174 | .0170 | .0166 | .0162 | .0158 | .0154 | .0150 | .0146 | .0143 |
| −2.0 | .0228 | .0222 | .0217 | .0212 | .0207 | .0202 | .0197 | .0192 | .0188 | .0183 |
| −1.9 | .0287 | .0281 | .0274 | .0268 | .0262 | .0256 | .0250 | .0244 | .0239 | .0233 |
| −1.8 | .0359 | .0352 | .0344 | .0336 | .0329 | .0322 | .0314 | .0307 | .0301 | .0294 |
| −1.7 | .0446 | .0436 | .0427 | .0418 | .0409 | .0401 | .0392 | .0384 | .0375 | .0367 |
| −1.6 | .0548 | .0537 | .0526 | .0516 | .0505 | .0495 | .0485 | .0475 | .0465 | .0455 |
| −1.5 | .0668 | .0655 | .0643 | .0630 | .0618 | .0606 | .0594 | .0582 | .0571 | .0559 |
| −1.4 | .0808 | .0793 | .0778 | .0764 | .0749 | .0735 | .0722 | .0708 | .0694 | .0681 |
| −1.3 | .0968 | .0951 | .0934 | .0918 | .0901 | .0885 | .0869 | .0853 | .0838 | .0823 |
| −1.2 | .1151 | .1131 | .1112 | .1093 | .1075 | .1056 | .1038 | .1020 | .1003 | .0985 |
| −1.1 | .1357 | .1335 | .1314 | .1292 | .1271 | .1251 | .1230 | .1210 | .1190 | .1170 |
| −1.0 | .1587 | .1562 | .1539 | .1515 | .1492 | .1469 | .1446 | .1423 | .1401 | .1379 |
| −0.9 | .1841 | .1814 | .1788 | .1762 | .1736 | .1711 | .1685 | .1660 | .1635 | .1611 |
| −0.8 | .2119 | .2090 | .2061 | .2033 | .2005 | .1977 | .1949 | .1922 | .1894 | .1867 |
| −0.7 | .2420 | .2389 | .2358 | .2327 | .2296 | .2266 | .2236 | .2206 | .2177 | .2148 |
| −0.6 | .2743 | .2709 | .2676 | .2643 | .2611 | .2578 | .2546 | .2514 | .2483 | .2451 |
| −0.5 | .3085 | .3050 | .3015 | .2981 | .2946 | .2912 | .2877 | .2843 | .2810 | .2776 |
| −0.4 | .3446 | .3409 | .3372 | .3336 | .3300 | .3264 | .3228 | .3192 | .3156 | .3121 |
| −0.3 | .3821 | .3783 | .3745 | .3707 | .3669 | .3632 | .3594 | .3557 | .3520 | .3482 |
| −0.2 | .4207 | .4168 | .4129 | .4090 | .4052 | .4013 | .3974 | .3936 | .3897 | .3859 |
| −0.1 | .4602 | .4562 | .4522 | .4483 | .4443 | .4404 | .4364 | .4325 | .4286 | .4247 |
| −0.0 | .5000 | .4960 | .4920 | .4880 | .4840 | .4801 | .4761 | .4721 | .4681 | .4641 |

(continued)

Table A.3 Standard Normal Curve Areas *(cont.)*

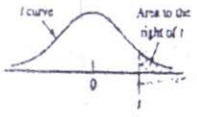
$\Phi(z) = P(Z \le z)$

| z | .00 | .01 | .02 | .03 | .04 | .05 | .06 | .07 | .08 | .09 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | .5000 | .5040 | .5080 | .5120 | .5160 | .5199 | .5239 | .5279 | .5319 | .5359 |
| 0.1 | .5398 | .5438 | .5478 | .5517 | .5557 | .5596 | .5636 | .5675 | .5714 | .5753 |
| 0.2 | .5793 | .5832 | .5871 | .5910 | .5948 | .5987 | .6026 | .6064 | .6103 | .6141 |
| 0.3 | .6179 | .6217 | .6255 | .6293 | .6331 | .6368 | .6406 | .6443 | .6480 | .6517 |
| 0.4 | .6554 | .6591 | .6628 | .6664 | .6700 | .6736 | .6772 | .6808 | .6844 | .6879 |
| 0.5 | .6915 | .6950 | .6985 | .7019 | .7054 | .7088 | .7123 | .7157 | .7190 | .7224 |
| 0.6 | .7257 | .7291 | .7324 | .7357 | .7389 | .7422 | .7454 | .7486 | .7517 | .7549 |
| 0.7 | .7580 | .7611 | .7642 | .7673 | .7704 | .7734 | .7764 | .7794 | .7823 | .7852 |
| 0.8 | .7881 | .7910 | .7939 | .7967 | .7995 | .8023 | .8051 | .8078 | .8106 | .8133 |
| 0.9 | .8159 | .8186 | .8212 | .8238 | .8264 | .8289 | .8315 | .8340 | .8365 | .8389 |
| 1.0 | .8413 | .8438 | .8461 | .8485 | .8508 | .8531 | .8554 | .8577 | .8599 | .8621 |
| 1.1 | .8643 | .8665 | .8686 | .8708 | .8729 | .8749 | .8770 | .8790 | .8810 | .8830 |
| 1.2 | .8849 | .8869 | .8888 | .8907 | .8925 | .8944 | .8962 | .8980 | .8997 | .9015 |
| 1.3 | .9032 | .9049 | .9066 | .9082 | .9099 | .9115 | .9131 | .9147 | .9162 | .9177 |
| 1.4 | .9192 | .9207 | .9222 | .9236 | .9251 | .9265 | .9278 | .9292 | .9306 | .9319 |
| 1.5 | .9332 | .9345 | .9357 | .9370 | .9382 | .9394 | .9406 | .9418 | .9429 | .9441 |
| 1.6 | .9452 | .9463 | .9474 | .9484 | .9495 | .9505 | .9515 | .9525 | .9535 | .9545 |
| 1.7 | .9554 | .9564 | .9573 | .9582 | .9591 | .9599 | .9608 | .9616 | .9625 | .9633 |
| 1.8 | .9641 | .9649 | .9656 | .9664 | .9671 | .9678 | .9686 | .9693 | .9699 | .9706 |
| 1.9 | .9713 | .9719 | .9726 | .9732 | .9738 | .9744 | .9750 | .9756 | .9761 | .9767 |
| 2.0 | .9772 | .9778 | .9783 | .9788 | .9793 | .9798 | .9803 | .9808 | .9812 | .9817 |
| 2.1 | .9821 | .9826 | .9830 | .9834 | .9838 | .9842 | .9846 | .9850 | .9854 | .9857 |
| 2.2 | .9861 | .9864 | .9868 | .9871 | .9875 | .9878 | .9881 | .9884 | .9887 | .9890 |
| 2.3 | .9893 | .9896 | .9898 | .9901 | .9904 | .9906 | .9909 | .9911 | .9913 | .9916 |
| 2.4 | .9918 | .9920 | .9922 | .9925 | .9927 | .9929 | .9931 | .9932 | .9934 | .9936 |
| 2.5 | .9938 | .9940 | .9941 | .9943 | .9945 | .9946 | .9948 | .9949 | .9951 | .9952 |
| 2.6 | .9953 | .9955 | .9956 | .9957 | .9959 | .9960 | .9961 | .9962 | .9963 | .9964 |
| 2.7 | .9965 | .9966 | .9967 | .9968 | .9969 | .9970 | .9971 | .9972 | .9973 | .9974 |
| 2.8 | .9974 | .9975 | .9976 | .9977 | .9977 | .9978 | .9979 | .9979 | .9980 | .9981 |
| 2.9 | .9981 | .9982 | .9982 | .9983 | .9984 | .9984 | .9985 | .9985 | .9986 | .9986 |
| 3.0 | .9987 | .9987 | .9987 | .9988 | .9988 | .9989 | .9989 | .9989 | .9990 | .9990 |
| 3.1 | .9990 | .9991 | .9991 | .9991 | .9992 | .9992 | .9992 | .9992 | .9993 | .9993 |
| 3.2 | .9993 | .9993 | .9994 | .9994 | .9994 | .9994 | .9994 | .9995 | .9995 | .9995 |
| 3.3 | .9995 | .9995 | .9995 | .9996 | .9996 | .9996 | .9996 | .9996 | .9996 | .9997 |
| 3.4 | .9997 | .9997 | .9997 | .9997 | .9997 | .9997 | .9997 | .9997 | .9997 | .9998 |





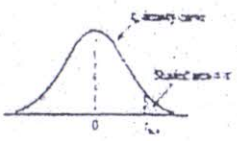
Table A.5 *t* Curve Tail Areas




| t | ν = 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | .500 | .500 | .500 | .500 | .500 | .500 | .500 | .500 | .500 | .500 | .500 | .500 | .500 | .500 | .500 | .500 | .500 | .500 |
| 0.1 | .468 | .465 | .463 | .463 | .462 | .462 | .462 | .461 | .461 | .461 | .461 | .461 | .461 | .461 | .461 | .461 | .461 | .461 |
| 0.2 | .437 | .430 | .427 | .426 | .425 | .424 | .424 | .423 | .423 | .423 | .423 | .422 | .422 | .422 | .422 | .422 | .422 | .422 |
| 0.3 | .407 | .396 | .392 | .390 | .388 | .387 | .386 | .386 | .386 | .385 | .385 | .385 | .384 | .384 | .384 | .384 | .384 | .384 |
| 0.4 | .379 | .364 | .358 | .355 | .353 | .352 | .351 | .350 | .349 | .349 | .348 | .348 | .348 | .347 | .347 | .347 | .347 | .347 |
| 0.5 | .352 | .333 | .326 | .322 | .319 | .317 | .316 | .315 | .315 | .314 | .313 | .313 | .313 | .312 | .312 | .312 | .312 | .312 |
| 0.6 | .328 | .305 | .295 | .290 | .287 | .285 | .284 | .283 | .282 | .281 | .280 | .280 | .279 | .279 | .279 | .278 | .278 | .278 |
| 0.7 | .306 | .278 | .267 | .261 | .258 | .255 | .253 | .252 | .251 | .250 | .249 | .249 | .248 | .247 | .247 | .247 | .247 | .246 |
| 0.8 | .285 | .254 | .241 | .234 | .230 | .227 | .225 | .223 | .222 | .221 | .220 | .220 | .219 | .218 | .218 | .218 | .217 | .217 |
| 0.9 | .267 | .232 | .217 | .210 | .205 | .201 | .199 | .197 | .196 | .195 | .194 | .193 | .192 | .191 | .191 | .191 | .190 | .190 |
| 1.0 | .250 | .211 | .196 | .187 | .182 | .178 | .175 | .173 | .172 | .170 | .169 | .169 | .168 | .167 | .167 | .166 | .166 | .165 |
| 1.1 | .235 | .193 | .176 | .167 | .162 | .157 | .154 | .152 | .150 | .149 | .147 | .146 | .146 | .144 | .144 | .144 | .143 | .143 |
| 1.2 | .221 | .177 | .158 | .148 | .142 | .138 | .135 | .132 | .130 | .129 | .128 | .127 | .126 | .124 | .124 | .124 | .123 | .123 |
| 1.3 | .209 | .162 | .142 | .132 | .125 | .121 | .117 | .115 | .113 | .111 | .110 | .109 | .108 | .107 | .107 | .106 | .105 | .105 |
| 1.4 | .197 | .148 | .128 | .117 | .110 | .106 | .102 | .100 | .098 | .096 | .095 | .093 | .092 | .091 | .091 | .090 | .090 | .089 |
| 1.5 | .187 | .136 | .115 | .104 | .097 | .092 | .089 | .086 | .084 | .082 | .081 | .080 | .079 | .078 | .077 | .077 | .076 | .075 |
| 1.6 | .178 | .125 | .104 | .092 | .085 | .080 | .077 | .074 | .072 | .070 | .069 | .068 | .067 | .065 | .065 | .065 | .064 | .064 |
| 1.7 | .169 | .116 | .094 | .082 | .075 | .070 | .065 | .064 | .062 | .060 | .059 | .057 | .056 | .055 | .055 | .054 | .054 | .053 |
| 1.8 | .161 | .107 | .085 | .073 | .066 | .061 | .057 | .055 | .053 | .051 | .050 | .049 | .048 | .046 | .046 | .045 | .045 | .044 |
| 1.9 | .154 | .099 | .077 | .065 | .058 | .053 | .050 | .047 | .045 | .043 | .042 | .041 | .040 | .038 | .038 | .038 | .037 | .037 |
| 2.0 | .148 | .092 | .070 | .058 | .051 | .046 | .043 | .040 | .038 | .037 | .035 | .034 | .033 | .032 | .032 | .031 | .031 | .030 |
| 2.1 | .141 | .085 | .063 | .052 | .045 | .040 | .037 | .034 | .033 | .031 | .030 | .029 | .028 | .027 | .027 | .026 | .025 | .025 |
| 2.2 | .136 | .079 | .058 | .046 | .040 | .035 | .032 | .029 | .028 | .026 | .025 | .024 | .023 | .022 | .022 | .021 | .021 | .021 |
| 2.3 | .131 | .074 | .052 | .041 | .035 | .031 | .027 | .025 | .023 | .022 | .021 | .020 | .019 | .018 | .018 | .018 | .017 | .017 |
| 2.4 | .126 | .069 | .048 | .037 | .031 | .027 | .024 | .022 | .020 | .019 | .018 | .017 | .016 | .015 | .015 | .014 | .014 | .014 |
| 2.5 | .121 | .065 | .044 | .033 | .027 | .023 | .020 | .018 | .017 | .016 | .015 | .014 | .013 | .012 | .012 | .012 | .011 | .011 |
| 2.6 | .117 | .061 | .040 | .030 | .024 | .020 | .018 | .016 | .014 | .013 | .012 | .012 | .011 | .010 | .010 | .010 | .009 | .009 |
| 2.7 | .113 | .057 | .037 | .027 | .021 | .018 | .015 | .014 | .012 | .011 | .010 | .010 | .009 | .008 | .008 | .008 | .008 | .007 |
| 2.8 | .109 | .054 | .034 | .024 | .019 | .016 | .013 | .012 | .010 | .009 | .009 | .008 | .008 | .007 | .007 | .006 | .006 | .006 |
| 2.9 | .106 | .051 | .031 | .022 | .017 | .014 | .011 | .010 | .009 | .008 | .007 | .007 | .006 | .005 | .005 | .005 | .005 | .005 |
| 3.0 | .102 | .048 | .029 | .020 | .015 | .012 | .010 | .009 | .007 | .007 | .006 | .006 | .005 | .004 | .004 | .004 | .004 | .004 |
| 3.1 | .099 | .045 | .027 | .018 | .013 | .011 | .009 | .007 | .006 | .006 | .005 | .005 | .004 | .004 | .004 | .003 | .003 | .003 |
| 3.2 | .096 | .043 | .025 | .016 | .012 | .009 | .008 | .006 | .005 | .005 | .004 | .004 | .003 | .003 | .003 | .003 | .003 | .002 |
| 3.3 | .094 | .040 | .023 | .015 | .011 | .008 | .007 | .005 | .005 | .004 | .004 | .003 | .003 | .002 | .002 | .002 | .002 | .002 |
| 3.4 | .091 | .038 | .021 | .014 | .010 | .007 | .006 | .005 | .004 | .003 | .003 | .003 | .002 | .002 | .002 | .002 | .002 | .002 |
| 3.5 | .089 | .036 | .020 | .012 | .009 | .006 | .005 | .004 | .003 | .003 | .002 | .002 | .002 | .002 | .002 | .001 | .001 | .001 |
| 3.6 | .086 | .035 | .018 | .011 | .008 | .006 | .004 | .004 | .003 | .002 | .002 | .002 | .002 | .001 | .001 | .001 | .001 | .001 |
| 3.7 | .084 | .033 | .017 | .010 | .007 | .005 | .004 | .003 | .002 | .002 | .002 | .002 | .001 | .001 | .001 | .001 | .001 | .001 |
| 3.8 | .082 | .031 | .016 | .010 | .006 | .004 | .003 | .003 | .002 | .002 | .001 | .001 | .001 | .001 | .001 | .001 | .001 | .001 |
| 3.9 | .080 | .030 | .015 | .009 | .006 | .004 | .003 | .002 | .002 | .001 | .001 | .001 | .001 | .001 | .001 | .001 | .001 | .001 |
| 4.0 | .078 | .029 | .014 | .008 | .005 | .004 | .003 | .002 | .002 | .001 | .001 | .001 | .001 | .001 | .001 | .001 | .000 | .000 |

*(continued)*

Table A.5 Critical Values for t Distributions




| | $\alpha$ | | | | | | |
|---|---|---|---|---|---|---|---|
| $\nu$ | .10 | .05 | .025 | .01 | .005 | .001 | .0005 |
| 1 | 3.078 | 6.314 | 12.706 | 31.821 | 63.657 | 318.31 | 636.62 |
| 2 | 1.886 | 2.920 | 4.303 | 6.965 | 9.925 | 22.326 | 31.598 |
| 3 | 1.638 | 2.353 | 3.182 | 4.541 | 5.841 | 10.213 | 12.924 |
| 4 | 1.533 | 2.132 | 2.776 | 3.747 | 4.604 | 7.173 | 8.610 |
| 5 | 1.476 | 2.015 | 2.571 | 3.365 | 4.032 | 5.893 | 6.869 |
| 6 | 1.440 | 1.943 | 2.447 | 3.143 | 3.707 | 5.208 | 5.959 |
| 7 | 1.415 | 1.895 | 2.365 | 2.998 | 3.499 | 4.785 | 5.408 |
| 8 | 1.397 | 1.860 | 2.306 | 2.896 | 3.355 | 4.501 | 5.041 |
| 9 | 1.383 | 1.833 | 2.262 | 2.821 | 3.250 | 4.297 | 4.781 |
| 10 | 1.372 | 1.812 | 2.228 | 2.764 | 3.169 | 4.144 | 4.587 |
| 11 | 1.363 | 1.796 | 2.201 | 2.718 | 3.106 | 4.025 | 4.437 |
| 12 | 1.356 | 1.782 | 2.179 | 2.681 | 3.055 | 3.930 | 4.318 |
| 13 | 1.350 | 1.771 | 2.160 | 2.650 | 3.012 | 3.852 | 4.221 |
| 14 | 1.345 | 1.761 | 2.145 | 2.624 | 2.977 | 3.787 | 4.140 |
| 15 | 1.341 | 1.753 | 2.131 | 2.602 | 2.947 | 3.733 | 4.073 |
| 16 | 1.337 | 1.746 | 2.120 | 2.583 | 2.921 | 3.686 | 4.015 |
| 17 | 1.333 | 1.740 | 2.110 | 2.567 | 2.898 | 3.646 | 3.965 |
| 18 | 1.330 | 1.734 | 2.101 | 2.552 | 2.878 | 3.610 | 3.922 |
| 19 | 1.328 | 1.729 | 2.093 | 2.539 | 2.861 | 3.579 | 3.883 |
| 20 | 1.325 | 1.725 | 2.086 | 2.528 | 2.845 | 3.552 | 3.850 |
| 21 | 1.323 | 1.721 | 2.080 | 2.518 | 2.831 | 3.527 | 3.819 |
| 22 | 1.321 | 1.717 | 2.074 | 2.508 | 2.819 | 3.505 | 3.792 |
| 23 | 1.319 | 1.714 | 2.069 | 2.500 | 2.807 | 3.485 | 3.767 |
| 24 | 1.318 | 1.711 | 2.064 | 2.492 | 2.797 | 3.467 | 3.745 |
| 25 | 1.316 | 1.708 | 2.060 | 2.485 | 2.787 | 3.450 | 3.725 |
| 26 | 1.315 | 1.706 | 2.056 | 2.479 | 2.779 | 3.435 | 3.707 |
| 27 | 1.314 | 1.703 | 2.052 | 2.473 | 2.771 | 3.421 | 3.690 |
| 28 | 1.313 | 1.701 | 2.048 | 2.467 | 2.763 | 3.408 | 3.674 |
| 29 | 1.311 | 1.699 | 2.045 | 2.462 | 2.756 | 3.396 | 3.659 |
| 30 | 1.310 | 1.697 | 2.042 | 2.457 | 2.750 | 3.385 | 3.646 |
| 32 | 1.309 | 1.694 | 2.037 | 2.449 | 2.738 | 3.365 | 3.622 |
| 34 | 1.307 | 1.691 | 2.032 | 2.441 | 2.728 | 3.348 | 3.601 |
| 36 | 1.306 | 1.688 | 2.028 | 2.434 | 2.719 | 3.333 | 3.582 |
| 38 | 1.304 | 1.686 | 2.024 | 2.429 | 2.712 | 3.319 | 3.566 |
| 40 | 1.303 | 1.684 | 2.021 | 2.423 | 2.704 | 3.307 | 3.551 |
| 50 | 1.299 | 1.676 | 2.009 | 2.403 | 2.678 | 3.262 | 3.496 |
| 60 | 1.296 | 1.671 | 2.000 | 2.390 | 2.660 | 3.232 | 3.460 |
| 120 | 1.289 | 1.658 | 1.980 | 2.358 | 2.617 | 3.160 | 3.373 |
| $\infty$ | 1.282 | 1.645 | 1.960 | 2.326 | 2.576 | 3.090 | 3.291 |