**University of Houston Mathematics Contest:  Statistics Exam 2019**
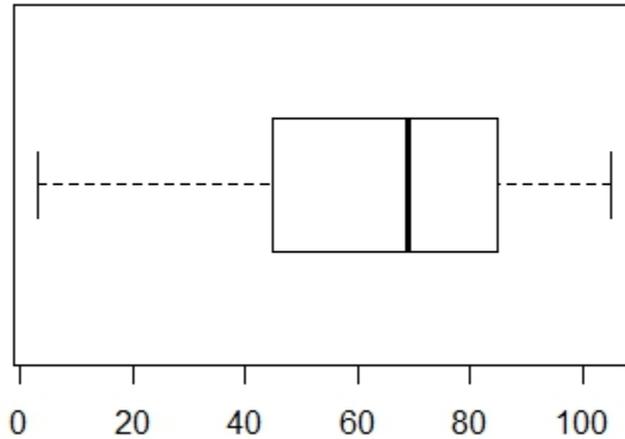
**Directions:** Select the best one answer. Tables are available at end of this test.

1. The following is a box plot of scores on a statistics exam.



   Which statement is false about the scores?

   a. The median score is about 70.
   b. The interquartile range is approximately 40.
   c. The shape is skewed left.
   d. The mean is less than the median.
   e. The mean score is 70.

2. Which list has the highest standard deviation?
   a. 20, 20, 20, 20, 20
   b. 100, 100, 100, 100, 100
   c. 1, 2, 3, 4, 5
   d. 1, 1, 3, 5, 5
   e. 100, 99, 98, 99, 100

3. The mean score of an Insurance Commission Licensure Examination is 75, with a standard deviation of 5. What minimum percentage of the data set that lies between 50 and 100?

   a. 99%
   b. 96%
   c. 4%
   d. 1%
   e. 20%

4. The following is the five number summary of 35 values.

   1.0  16.0  48.5  67.0 100.0

   How many numbers are strictly less than 67?

   a. 26
   b. 9
   c. 17
   d. 8
   e. 2

5. The following is a stem plot of the number of wins for 38 baseball teams in one season.

```
The decimal point is 1 digit(s) to the right of the |
   2 | 679
   3 | 8
   4 | 1246678
   5 | 022223345677889
   6 | 1234577
   7 | 0019
   8 | 6
```

What is the median of the number of wins?

   a. 5.5
   b. 54
   c. 55
   d. 54.5
   e. 5.0

6. Suppose a density curve is defined by the function $f(x) = 2 - 2x$ for all values between $x = 0$ to $x = 1$. Find the median of this density curve. (Round to the nearest hundredths)
   a. 0.50
   b. 0.29
   c. 1.00
   d. 0.03
   e. 1.71

7. A girl scores 22 in math on the ACT. Suppose the distribution is approximately normal and the mean of the ACT is 19 with a standard deviation of 6. Suppose the mean of the math SAT was 490 with a standard deviation of 140 with a normal distribution. What should be the score of her math SAT if the z-score is the same as the math ACT?
   a. 600
   b. 493
   c. 420
   d. 490
   e. 560

8. The test scores of a class of 30 students have a mean of 75.6 and the test scores of another class of 24 students have a mean of 68.4. Find the mean of the combined group.
   a. 72.0
   b. 68.0
   c. 75.6
   d. 68.4
   e. 72.4

9. Given the following probability distribution:

| X | -18 | -14 | 2 | 11 | 20 |
|------|------|------|------|-------|------|
| P(X) | 1⁄25 | 3⁄50 | 1⁄20 | 1⁄100 | ___ |

Determine the variance of this distribution.

   a. 15.45
   b. 3.93
   c. 362.13
   d. 123.43
   e. 11.11

10. This game consists of selecting a three-digit number (000 to 999). If you guess the right number, you are paid $500 for each dollar you bet. Each day there is a new winning number. If a person bets $1 each day for 1 year, how much money can he expect to win (or lose)?
    a. $166.00
    b. -$50.00
    c. -$182.50
    d. $249.00
    e. -$365.00

11. A person has a 5% chance of winning a free ticket in a state lottery. If she plays the game 25 times, what is the probability she will win at least one free ticket?
    a. 0.125
    b. 0.277
    c. 0.635
    d. 0.723
    e. 0.002

12. In the past year, 10% of RGH Airlines flights violated one or more safety codes. A government inspector decided to monitor two flights per day for the next 30 days. Let $x$ be the number of flights that violate one or more safety codes.  How many flights do we expect to violate one or more safety codes?
    a. 6
    b. 1.6
    c. 3
    d. 5.4
    e. 2

13. At a certain car dealership, if you select a Ford Mustang at random, the probability it is red is P(R) = 0.40, the probability it is a red convertible P(R ∩ C) = 0.04, and the probability that it is red or a convertible P(R ∪ C) = 0.50.  What is the probability that out of the convertibles the car is red?
    a. 0.04
    b. 0.10
    c. 0.14
    d. 0.29
    e. 0.50

14. Seventy percent of the light aircraft that disappear while in flight in a certain country are subsequently discovered. Of the aircraft that are discovered, 60% have an emergency locator, whereas 90% of the aircraft not discovered do not have such a locator. Suppose a light aircraft has disappeared.  If it has an emergency locator, what is the probability that it will not be discovered?
    a.  0.067
    b.  0.100
    c.  0.030
    d.  0.54
    e.  0.001

15. Given $P(A) = 0.6$, $P(B) = 0.5$ and $P(A \cap B) = 0.1$.  Which statement is correct?
    a.  Events A and B are independent.
    b.  Events A and B are mutually exclusive (disjoint).
    c.  $P(B \mid A) = 0.833$
    d.  One of the two events, A or B will always happen.
    e.  None of these are true.

16. The Edwards's Theater chain has studied its movie customers to determine how much money they spend on concessions. The study revealed that the spending distribution is approximately normally distributed with a mean of $4.11 and a standard deviation of $1.37. What percentage of customers will spend more than $5.00 on concessions?
    a.  26%
    b.  33%
    c.  65%
    d.  74%
    e.  82%

17. Scores on the GMAT are roughly normally distributed with a mean of 527 and a standard deviation of 112.  How high must an individual score on the GMAT in order to score in the highest 10%?
    a.  143.5
    b.  164.5
    c.  263.5
    d.  381.5
    e.  670.36

18. The monthly expenditures on food by a single adult living in a certain neighborhood are normally distributed with a mean of $370 and standard deviation of $80. Determine the percentage of samples, of size 16, that have a mean expenditure within $10 of the population mean.
    a.  5%
    b.  10%
    c.  38%
    d.  68%
    e.  95%

19. Suppose that the mean of test scores are 71.2 points with a standard deviation of 12 points with a normal distribution. The instructor decided that anything below a 70 is failing. What is the probability that out of the passing grades that a student gets 90 points or higher?
    a.  0.058
    b.  0.108
    c.  0.488
    d.  0.539
    e.  0.941

20. The heights of a random sample of students taking this test were recorded in inches. They were then converted to centimeters by 1 inch = 2.54 centimeters. What is correlation between the heights in inches and the heights in centimeters?
    a.  2.54
    b.  0.5
    c.  -1.0
    d.  1.0
    e.  Cannot be determined by the information given.

21. Suppose that the least squares regression line for predicting $y$ from $x$ is $\hat{y} = 100 + 1.5x$. Which of the following is a *possible* value for a correlation between $y$ and $x$?
    a.  1.5
    b.  -1.5
    c.  0
    d.  -0.6
    e.  0.6

22. A report in a medical journal notes that the risk of developing Alzheimer's disease among subjects who (voluntarily) regularly took the anti-inflammatory drug ibuprofen was about half the risk among those who did not. Is this good evidence that ibuprofen is effective in preventing Alzheimer's disease?
    a. Yes, because this was a randomized, comparative experiment.
    b. No, because the effect of ibuprofen is compounded with the placebo effect.
    c. Yes, because the results were published in a reputable professional journal.
    d. No, because this is an observational study.
    e. Yes, because a 50% reduction cannot happen just by chance.

23. A small company of 60 people asked all of their employees if they do volunteer service in their community. From census, they found that 62% did volunteer service. Which statement is correct?
    a. We are 95% confident that between 49.7% and 74.3% of the employees do volunteer service.
    b. There is a 95% chance that between 49.7% and 74.3% of the employees do volunteer service.
    c. If we take several samples, 95% of the samples would find that 62% of the employees in the sample do volunteer service.
    d. A confidence interval is not needed here.
    e. All of these statements are true.

24. Using the hypotheses $H_0$: $\mu = 25$ and $H_A$: $\mu > 25$ we get p-value = 0.015. Which of the following is correct?
    I. There is a 1.5% chance that the mean is greater than 25.
    II. The probability of getting the observed value or greater, assuming that the population mean is 25, is 0.015.
    III. At 5% level of significance, we would fail to reject the null hypothesis.

    a. I is correct.
    b. II is correct.
    c. III is correct.
    d. II and III are correct.
    e. All three statements are correct.

25. We want to know if the mean MPG of a Toyota Prius is different than the mean MPG of a Honda Civic. The hypotheses of testing if the means are different is:
    a. $H_0$: $\mu_{Prius} \neq \mu_{Civic}$ and $H_A$: $\mu_{Prius} > \mu_{Civic}$
    b. $H_0$: $\mu_{Prius} = \mu_{Civic}$ and $H_A$: $\mu_{Prius} > \mu_{Civic}$
    c. $H_0$: $\mu_{Prius} = \mu_{Civic}$ and $H_A$: $\mu_{Prius} < \mu_{Civic}$
    d. $H_0$: $\mu_{Prius} = \mu_{Civic}$ and $H_A$: $\mu_{Prius} \neq \mu_{Civic}$
    e. $H_0$: $\bar{x}_{Prius} = \bar{x}_{Civic}$ and $H_A$: $\bar{x}_{Prius} \neq \bar{x}_{Civic}$

26. Which one of the following would be best to use the matched pair t-test?
    a. The mean number of cigarettes smoked per day by 14 men who have had strokes compared with the mean number smoked by 14 men who have not had strokes.
    b. The photosynthetic rates of 10 randomly chosen Douglas-fir trees compared with 10 randomly chosen western red cedar trees.
    c. The photosynthetic rate measured on 10 randomly chosen Sitka spruce trees compared with the rate measured on the western red cedar growing next to each of the Sitka spruce trees.
    d. All of these should use the matched pair t-test.
    e. None of these should use the matched pair t-test.


Use the following information to answer questions 27 and 28:

The following output of a least squares equation based on a sample of 14 used cars.  We wanted to determine the cost of a car based on the age.

```
Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  18357.7     1817.4  10.101 3.21e-07 ***
Age          -1533.6      306.3  -5.008 0.000305 ***
```


27. If the car is 6 years old, determined the predicted cost of the car.
    a. $ 9,156.10
    b. $ 27,559.30
    c. $ 108,612.60
    d. $ 111,679.80
    e. $ 1,533.60


28. Conduct a hypothesis test to determine if the slope is negative.  Give the p-value and conclusion.
    a. P-value = 0.000305, there is extremely strong evidence that for each additional year, the price of the automobile decreases by $1533.60 or more.
    b. P-value = 0.0001525, there is extremely strong evidence that the cost of the car decreases for each additional year.
    c. P-value = 0.00001, there is no evidence that the cost of the car decreases for each additional year.
    d. P-value = 0.000305, there is extremely strong evidence that the cost of the car decreases for each additional year.
    e. P-value = 0.0001525, there is no evidence that the cost of the car decreases for each additional year.

Use the following information to answer questions 29 and 30:

The operations manager of a company that manufactures tires wants to determine whether there are any differences in the quality of workmanship among the three daily shifts. She randomly selects 506 tires and carefully inspects them. Each tire is either classified as perfect, satisfactory, or defective, and the shift that produced it is also recorded. The two categorical variables of interest are: shift and condition of the tire produced. The data can be summarized by the accompanying two-way table:

|  | **Perfect** | **Satisfactory** | **Defective** | Total |
|---|---|---|---|---|
| **Shift 1** | 106 | 124 | 5 | 235 |
| **Shift 2** | 67 | 85 | 6 | 158 |
| **Shift 3** | 37 | 72 | 4 | 113 |
| Total | 210 | 281 | 15 | 506 |

29. From this sample of 506 tires, what percent of tires that were produced in shift 3 are defective?
    a. 3.0%
    b. 22.3%
    c. 3.5%
    d. 26.7%
    e. 0.8%

30. Do these data provide sufficient evidence at the 5% significance level to infer that there are differences in quality among the three shifts?  Give the test statistic, p-value and conclusion.
    a. $X^2 = 0.554$, p-value = 0.2244, There is evidence to infer that there are differences in the quality among the three shifts.
    b. $X^2 = 5.679$, p-value = 0.2244, There is evidence to infer that there are differences in the quality among the three shifts.
    c. $Z = 5.679$, p-value = 0.0001, There is evidence to infer that there are differences in the quality among the three shifts.
    d. $X^2 = 5.679$, p-value = 0.2244, There is no evidence to infer that there are differences in the quality among the three shifts.
    e. $Z = 5.679$, p-value = 0.0001, There is no evidence to infer that there are differences in the quality among the three shifts.

This page is intentionally left blank. Tables can be found on the following pages.

# Table of Standard Normal Probabilities for Negative Z-scores
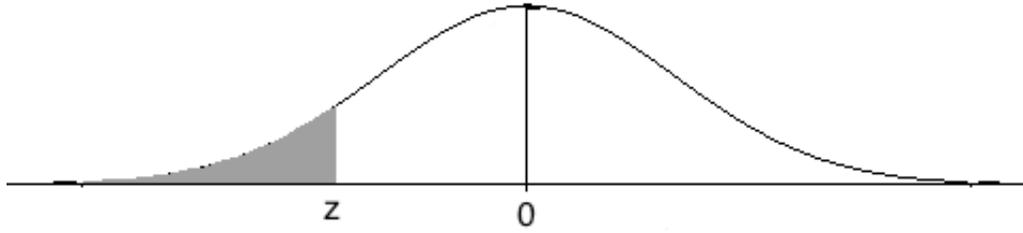


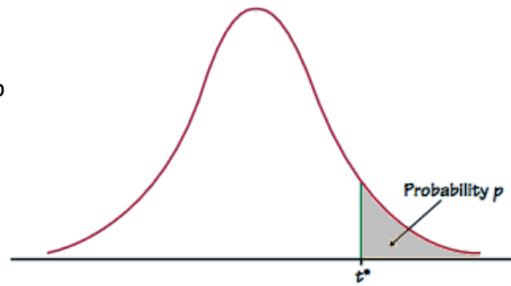| z | 0.00 | 0.01 | 0.02 | 0.03 | 0.04 | 0.05 | 0.06 | 0.07 | 0.08 | 0.09 |
|------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| -3.4 | 0.0003 | 0.0003 | 0.0003 | 0.0003 | 0.0003 | 0.0003 | 0.0003 | 0.0003 | 0.0003 | 0.0002 |
| -3.3 | 0.0005 | 0.0005 | 0.0005 | 0.0004 | 0.0004 | 0.0004 | 0.0004 | 0.0004 | 0.0004 | 0.0003 |
| -3.2 | 0.0007 | 0.0007 | 0.0006 | 0.0006 | 0.0006 | 0.0006 | 0.0006 | 0.0005 | 0.0005 | 0.0005 |
| -3.1 | 0.0010 | 0.0009 | 0.0009 | 0.0009 | 0.0008 | 0.0008 | 0.0008 | 0.0008 | 0.0007 | 0.0007 |
| -3.0 | 0.0013 | 0.0013 | 0.0013 | 0.0012 | 0.0012 | 0.0011 | 0.0011 | 0.0011 | 0.0010 | 0.0010 |
| -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 | 0.2389 | 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 | 0.2483 | 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 of Standard Normal Probabilities for Positive Z-scores



| 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 | 0.7517 | 0.7549 |
| 0.7 | 0.7580 | 0.7611 | 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 | 0.9987 | 0.9987 | 0.9987 | 0.9988 | 0.9988 | 0.9989 | 0.9989 | 0.9989 | 0.9990 | 0.9990 |
| 3.1 | 0.9990 | 0.9991 | 0.9991 | 0.9991 | 0.9992 | 0.9992 | 0.9992 | 0.9992 | 0.9993 | 0.9993 |
| 3.2 | 0.9993 | 0.9993 | 0.9994 | 0.9994 | 0.9994 | 0.9994 | 0.9994 | 0.9995 | 0.9995 | 0.9995 |
| 3.3 | 0.9995 | 0.9995 | 0.9995 | 0.9996 | 0.9996 | 0.9996 | 0.9996 | 0.9996 | 0.9996 | 0.9997 |
| 3.4 | 0.9997 | 0.9997 | 0.9997 | 0.9997 | 0.9997 | 0.9997 | 0.9997 | 0.9997 | 0.9997 | 0.9998 |

Table entry for p and C is the critical value t* with probability p lying to its right and probability C lying between –t* and t*



Probability p

t*

| df | 0.25 | 0.20 | 0.15 | 0.10 | 0.05 | 0.025 | 0.02 | 0.01 | 0.005 | 0.0025 | 0.001 | 0.0005 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Upper tail probability p | | | | |
| 1 | 1.000 | 1.376 | 1.963 | 3.078 | 6.314 | 12.706 | 15.895 | 31.821 | 63.657 | 127.321 | 318.309 | 636.619 |
| 2 | 0.8165 | 1.0607 | 1.3862 | 1.8856 | 2.9200 | 4.3027 | 4.8487 | 6.9646 | 9.9248 | 14.0890 | 22.3271 | 31.5991 |
| 3 | 0.7649 | 0.9785 | 1.2498 | 1.6377 | 2.3534 | 3.1824 | 3.4819 | 4.5407 | 5.8409 | 7.4533 | 10.2145 | 12.9240 |
| 4 | 0.7407 | 0.9410 | 1.1896 | 1.5332 | 2.1318 | 2.7764 | 2.9985 | 3.7469 | 4.6041 | 5.5976 | 7.1732 | 8.6103 |
| 5 | 0.7267 | 0.9195 | 1.1558 | 1.4759 | 2.0150 | 2.5706 | 2.7565 | 3.3649 | 4.0321 | 4.7733 | 5.8934 | 6.8688 |
| 6 | 0.7176 | 0.9057 | 1.1342 | 1.4398 | 1.9432 | 2.4469 | 2.6122 | 3.1427 | 3.7074 | 4.3168 | 5.2076 | 5.9588 |
| 7 | 0.7111 | 0.8960 | 1.1192 | 1.4149 | 1.8946 | 2.3646 | 2.5168 | 2.9980 | 3.4995 | 4.0293 | 4.7853 | 5.4079 |
| 8 | 0.7064 | 0.8889 | 1.1081 | 1.3968 | 1.8595 | 2.3060 | 2.4490 | 2.8965 | 3.3554 | 3.8325 | 4.5008 | 5.0413 |
| 9 | 0.7027 | 0.8834 | 1.0997 | 1.3830 | 1.8331 | 2.2622 | 2.3984 | 2.8214 | 3.2498 | 3.6897 | 4.2968 | 4.7809 |
| 10 | 0.6998 | 0.8791 | 1.0931 | 1.3722 | 1.8125 | 2.2281 | 2.3593 | 2.7638 | 3.1693 | 3.5814 | 4.1437 | 4.5869 |
| 11 | 0.6974 | 0.8755 | 1.0877 | 1.3634 | 1.7959 | 2.2010 | 2.3281 | 2.7181 | 3.1058 | 3.4966 | 4.0247 | 4.4370 |
| 12 | 0.6955 | 0.8726 | 1.0832 | 1.3562 | 1.7823 | 2.1788 | 2.3027 | 2.6810 | 3.0545 | 3.4284 | 3.9296 | 4.3178 |
| 13 | 0.6938 | 0.8702 | 1.0795 | 1.3502 | 1.7709 | 2.1604 | 2.2816 | 2.6503 | 3.0123 | 3.3725 | 3.8520 | 4.2208 |
| 14 | 0.6924 | 0.8681 | 1.0763 | 1.3450 | 1.7613 | 2.1448 | 2.2638 | 2.6245 | 2.9768 | 3.3257 | 3.7874 | 4.1405 |
| 15 | 0.6912 | 0.8662 | 1.0735 | 1.3406 | 1.7531 | 2.1314 | 2.2485 | 2.6025 | 2.9467 | 3.2860 | 3.7328 | 4.0728 |
| 16 | 0.6901 | 0.8647 | 1.0711 | 1.3368 | 1.7459 | 2.1199 | 2.2354 | 2.5835 | 2.9208 | 3.2520 | 3.6862 | 4.0150 |
| 17 | 0.6892 | 0.8633 | 1.0690 | 1.3334 | 1.7396 | 2.1098 | 2.2238 | 2.5669 | 2.8982 | 3.2224 | 3.6458 | 3.9651 |
| 18 | 0.6884 | 0.8620 | 1.0672 | 1.3304 | 1.7341 | 2.1009 | 2.2137 | 2.5524 | 2.8784 | 3.1966 | 3.6105 | 3.9216 |
| 19 | 0.6876 | 0.8610 | 1.0655 | 1.3277 | 1.7291 | 2.0930 | 2.2047 | 2.5395 | 2.8609 | 3.1737 | 3.5794 | 3.8834 |
| 20 | 0.6870 | 0.8600 | 1.0640 | 1.3253 | 1.7247 | 2.0860 | 2.1967 | 2.5280 | 2.8453 | 3.1534 | 3.5518 | 3.8495 |
| 21 | 0.6864 | 0.8591 | 1.0627 | 1.3232 | 1.7207 | 2.0796 | 2.1894 | 2.5176 | 2.8314 | 3.1352 | 3.5272 | 3.8193 |
| 22 | 0.6858 | 0.8583 | 1.0614 | 1.3212 | 1.7171 | 2.0739 | 2.1829 | 2.5083 | 2.8188 | 3.1188 | 3.5050 | 3.7921 |
| 23 | 0.6853 | 0.8575 | 1.0603 | 1.3195 | 1.7139 | 2.0687 | 2.1770 | 2.4999 | 2.8073 | 3.1040 | 3.4850 | 3.7676 |
| 24 | 0.6848 | 0.8569 | 1.0593 | 1.3178 | 1.7109 | 2.0639 | 2.1715 | 2.4922 | 2.7969 | 3.0905 | 3.4668 | 3.7454 |
| 25 | 0.6844 | 0.8562 | 1.0584 | 1.3163 | 1.7081 | 2.0595 | 2.1666 | 2.4851 | 2.7874 | 3.0782 | 3.4502 | 3.7251 |
| 26 | 0.6840 | 0.8557 | 1.0575 | 1.3150 | 1.7056 | 2.0555 | 2.1620 | 2.4786 | 2.7787 | 3.0669 | 3.4350 | 3.7066 |
| 27 | 0.6837 | 0.8551 | 1.0567 | 1.3137 | 1.7033 | 2.0518 | 2.1578 | 2.4727 | 2.7707 | 3.0565 | 3.4210 | 3.6896 |
| 28 | 0.6834 | 0.8546 | 1.0560 | 1.3125 | 1.7011 | 2.0484 | 2.1539 | 2.4671 | 2.7633 | 3.0469 | 3.4082 | 3.6739 |
| 29 | 0.6830 | 0.8542 | 1.0553 | 1.3114 | 1.6991 | 2.0452 | 2.1503 | 2.4620 | 2.7564 | 3.0380 | 3.3962 | 3.6594 |
| 30 | 0.6828 | 0.8538 | 1.0547 | 1.3104 | 1.6973 | 2.0423 | 2.1470 | 2.4573 | 2.7500 | 3.0298 | 3.3852 | 3.6460 |
| 40 | 0.6807 | 0.8507 | 1.0500 | 1.3031 | 1.6839 | 2.0211 | 2.1229 | 2.4233 | 2.7045 | 2.9712 | 3.3069 | 3.5510 |
| 50 | 0.6794 | 0.8489 | 1.0473 | 1.2987 | 1.6759 | 2.0086 | 2.1087 | 2.4033 | 2.6778 | 2.9370 | 3.2614 | 3.4960 |
| 60 | 0.6786 | 0.8477 | 1.0455 | 1.2958 | 1.6706 | 2.0003 | 2.0994 | 2.3901 | 2.6603 | 2.9146 | 3.2317 | 3.4602 |
| 80 | 0.6776 | 0.8461 | 1.0432 | 1.2922 | 1.6641 | 1.9901 | 2.0878 | 2.3739 | 2.6387 | 2.8870 | 3.1953 | 3.4163 |
| 100 | 0.6770 | 0.8452 | 1.0418 | 1.2901 | 1.6602 | 1.9840 | 2.0809 | 2.3642 | 2.6259 | 2.8707 | 3.1737 | 3.3905 |
| 1000 | 0.6747 | 0.8420 | 1.0370 | 1.2824 | 1.6464 | 1.9623 | 2.0564 | 2.3301 | 2.5808 | 2.8133 | 3.0984 | 3.3003 |
| z* | 0.6745 | 0.8416 | 1.0364 | 1.2816 | 1.6449 | 1.9600 | 2.0537 | 2.3263 | 2.5758 | 2.8070 | 3.0902 | 3.2905 |
| | 50% | 60% | 70% | 80% | 90% | 95% | 96% | 98% | 99% | 99.5% | 99.8% | 99.9% |

Confidence Level C

Table entry for p is the critical value $\chi^2$ with probability p lying to its right.

Probability p

$\chi^2$
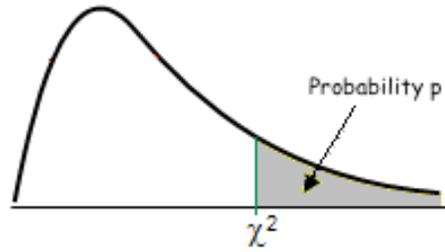
| | Upper tail probability p | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| df | 0.25 | 0.20 | 0.15 | 0.10 | 0.05 | 0.025 | 0.02 | 0.01 | 0.005 | 0.0025 | 0.001 | 0.0005 |
| 1 | 1.323 | 1.642 | 2.072 | 2.706 | 3.841 | 5.024 | 5.412 | 6.635 | 7.879 | 9.141 | 10.828 | 12.116 |
| 2 | 2.773 | 3.219 | 3.794 | 4.605 | 5.991 | 7.378 | 7.824 | 9.210 | 10.597 | 11.983 | 13.816 | 15.202 |
| 3 | 4.108 | 4.642 | 5.317 | 6.251 | 7.815 | 9.348 | 9.837 | 11.345 | 12.838 | 14.320 | 16.266 | 17.730 |
| 4 | 5.385 | 5.989 | 6.745 | 7.779 | 9.488 | 11.143 | 11.668 | 13.277 | 14.860 | 16.424 | 18.467 | 19.997 |
| 5 | 6.626 | 7.289 | 8.115 | 9.236 | 11.070 | 12.833 | 13.388 | 15.086 | 16.750 | 18.386 | 20.515 | 22.105 |
| 6 | 7.841 | 8.558 | 9.446 | 10.645 | 12.592 | 14.449 | 15.033 | 16.812 | 18.548 | 20.249 | 22.458 | 24.103 |
| 7 | 9.037 | 9.803 | 10.748 | 12.017 | 14.067 | 16.013 | 16.622 | 18.475 | 20.278 | 22.040 | 24.322 | 26.018 |
| 8 | 10.219 | 11.030 | 12.027 | 13.362 | 15.507 | 17.535 | 18.168 | 20.090 | 21.955 | 23.774 | 26.124 | 27.868 |
| 9 | 11.389 | 12.242 | 13.288 | 14.684 | 16.919 | 19.023 | 19.679 | 21.666 | 23.589 | 25.462 | 27.877 | 29.666 |
| 10 | 12.549 | 13.442 | 14.534 | 15.987 | 18.307 | 20.483 | 21.161 | 23.209 | 25.188 | 27.112 | 29.588 | 31.420 |
| 11 | 13.701 | 14.631 | 15.767 | 17.275 | 19.675 | 21.920 | 22.618 | 24.725 | 26.757 | 28.729 | 31.264 | 33.137 |
| 12 | 14.845 | 15.812 | 16.989 | 18.549 | 21.026 | 23.337 | 24.054 | 26.217 | 28.300 | 30.318 | 32.909 | 34.821 |
| 13 | 15.984 | 16.985 | 18.202 | 19.812 | 22.362 | 24.736 | 25.472 | 27.688 | 29.819 | 31.883 | 34.528 | 36.478 |
| 14 | 17.117 | 18.151 | 19.406 | 21.064 | 23.685 | 26.119 | 26.873 | 29.141 | 31.319 | 33.426 | 36.123 | 38.109 |
| 15 | 18.245 | 19.311 | 20.603 | 22.307 | 24.996 | 27.488 | 28.259 | 30.578 | 32.801 | 34.950 | 37.697 | 39.719 |
| 16 | 19.369 | 20.465 | 21.793 | 23.542 | 26.296 | 28.845 | 29.633 | 32.000 | 34.267 | 36.456 | 39.252 | 41.308 |
| 17 | 20.489 | 21.615 | 22.977 | 24.769 | 27.587 | 30.191 | 30.995 | 33.409 | 35.718 | 37.946 | 40.790 | 42.879 |
| 18 | 21.605 | 22.760 | 24.155 | 25.989 | 28.869 | 31.526 | 32.346 | 34.805 | 37.156 | 39.422 | 42.312 | 44.434 |
| 19 | 22.718 | 23.900 | 25.329 | 27.204 | 30.144 | 32.852 | 33.687 | 36.191 | 38.582 | 40.885 | 43.820 | 45.973 |
| 20 | 23.828 | 25.038 | 26.498 | 28.412 | 31.410 | 34.170 | 35.020 | 37.566 | 39.997 | 42.336 | 45.315 | 47.498 |
| 21 | 24.935 | 26.171 | 27.662 | 29.615 | 32.671 | 35.479 | 36.343 | 38.932 | 41.401 | 43.775 | 46.797 | 49.011 |
| 22 | 26.039 | 27.301 | 28.822 | 30.813 | 33.924 | 36.781 | 37.659 | 40.289 | 42.796 | 45.204 | 48.268 | 50.511 |
| 23 | 27.141 | 28.429 | 29.979 | 32.007 | 35.172 | 38.076 | 38.968 | 41.638 | 44.181 | 46.623 | 49.728 | 52.000 |
| 24 | 28.241 | 29.553 | 31.132 | 33.196 | 36.415 | 39.364 | 40.270 | 42.980 | 45.559 | 48.034 | 51.179 | 53.479 |
| 25 | 29.339 | 30.675 | 32.282 | 34.382 | 37.652 | 40.646 | 41.566 | 44.314 | 46.928 | 49.435 | 52.620 | 54.947 |
| 26 | 30.435 | 31.795 | 33.429 | 35.563 | 38.885 | 41.923 | 42.856 | 45.642 | 48.290 | 50.829 | 54.052 | 56.407 |
| 27 | 31.528 | 32.912 | 34.574 | 36.741 | 40.113 | 43.195 | 44.140 | 46.963 | 49.645 | 52.215 | 55.476 | 57.858 |
| 28 | 32.620 | 34.027 | 35.715 | 37.916 | 41.337 | 44.461 | 45.419 | 48.278 | 50.993 | 53.594 | 56.892 | 59.300 |
| 29 | 33.711 | 35.139 | 36.854 | 39.087 | 42.557 | 45.722 | 46.693 | 49.588 | 52.336 | 54.967 | 58.301 | 60.735 |
| 30 | 34.800 | 36.250 | 37.990 | 40.256 | 43.773 | 46.979 | 47.962 | 50.892 | 53.672 | 56.332 | 59.703 | 62.162 |
| 40 | 45.616 | 47.269 | 49.244 | 51.805 | 55.758 | 59.342 | 60.436 | 63.691 | 66.766 | 69.699 | 73.402 | 76.095 |
| 50 | 56.334 | 58.164 | 60.346 | 63.167 | 67.505 | 71.420 | 72.613 | 76.154 | 79.490 | 82.664 | 86.661 | 89.561 |
| 60 | 66.981 | 68.972 | 71.341 | 74.397 | 79.082 | 83.298 | 84.580 | 88.379 | 91.952 | 95.344 | 99.607 | 102.695 |
| 80 | 88.130 | 90.405 | 93.106 | 96.578 | 101.879 | 106.629 | 108.069 | 112.329 | 116.321 | 120.102 | 124.839 | 128.261 |
| 100 | 109.141 | 111.667 | 114.659 | 118.498 | 124.342 | 129.561 | 131.142 | 135.807 | 140.169 | 144.293 | 149.449 | 153.167 |