# Practice Exam 2

**Name**: ______________________________________________.

**Student ID**: ______________________________________________.

**Instruction**:
- This exam is closed book, but you may use one-sided formula sheet with handwritten notes.
- Calculators are allowed, but no other electronic devices are allowed.
- No partial credit in any case.
- Only scantron answers will be graded.

**Academic Misconduct:** Any potential violation of UCLA's policy on academic integrity will be reported to the Office of the Dean of Students. All work on this exam must be your own.

Please sign, if you understand and agree with the instruction and academic misconduct.

**Signature**: ______________________________________________.

*Source: Much of this review material is adapted from review materials prepared by Vivian Lew for her Stats 10 class in Spring 2014.*

**Problem 1.** Please determine whether the variable would best be modeled as continuous or discrete: The number of "Yes" votes a ballot proposition received in an election.

(a) Continuous
(b) Discrete

**Problem 2.** Please determine whether the variable would best be modeled as continuous or discrete: The weight of babies born in North Carolina in 2009.

(a) Continuous
(b) Discrete

**Problem 3.** Please determine whether the variable would best be modeled as continuous or discrete: The temperature of a greenhouse at a certain time of the day.

(a) Continuous
(b) Discrete

**Problem 4** Please determine whether the variable would best be modeled as continuous or discrete: The number of tomatoes harvested each week from a greenhouse tomato plant.

(a) Continuous
(b) Discrete

**(Problems 5-6)** Male players at the high school, college, and professional ranks use a regulation basketball that weighs 22.0 ounces with a standard deviation of 1.0 ounce. Assume that the weights of basketballs are approximately Normally distributed.

**Problem 5.** Roughly what percentage of regulation basketballs weigh less than 20.7 ounces? Round to the nearest tenth of a percent.

(a) 4.3% of the basketballs will weigh less than 20.7 ounces.
(b) 22.3% of the basketballs will weigh less than 20.7 ounces.

(c) 9.7% of the basketballs will weigh less than 20.7 ounces.
(d) 5.7% of the basketballs will weigh less than 20.7 ounces.

**Problem 6.** If a regulation basketball is randomly selected, what is the probability that it will weigh between 20.5 and 23.5 ounces? Round to the nearest thousandth.

(a) .866
(b) .134
(c) .267
(d) .704

**Problem 7**. The Normal model N(58, 21) describes the distribution of weights of chicken eggs in grams. Suppose that the weight of a randomly selected chicken egg has a z-score of 1.78. What is the weight of this egg in grams? Round to the nearest hundredth of a gram.

(a) 95.38 grams
(b) 89.50 grams
(c) 65.25 grams
(d) 79.50 grams

**(Problems 8-9)** The mean travel time to work for a person working in Kokomo, Indiana, is 17 minutes. Suppose the standard deviation of travel time to work is 4.5 minutes and the distribution of travel time is approximately Normally distributed.

**Problem 8.** Approximately what percentage of people living and working in Kokomo have a travel time to work that is at least 20 minutes? Round to the nearest whole percent.

(a) 75%
(b) 25%
(c) 15%
(d) None of the above

**Problem 9.** Suppose that it is reported in the news that 12% of the people living and working in Kokomo feel that their commute is too long. What is the travel time to work that separates the top 12% of people with the longest travel times and the lower 88%? Round to the nearest tenth of a minute.

(a) 26.0 minutes
(b) 18.1 minutes
(c) 22.3 minutes
(d) None of the above

**(Problems 10-13)** Suppose that the probability that a person books a hotel using an online travel website is .7. Consider a sample of fifteen randomly selected people who recently booked a hotel.

**Problem 10.** What is the probability that exactly ten people out of fifteen people used an online travel website when they booked their hotel? Round to the nearest thousandth.

(a) .206
(b) .036
(c) .001
(d) .723

**Problem 11.** What is the probability that at least fourteen out of fifteen people used an online travel website when they booked their hotel? Round to the nearest thousandth.

(a) .206
(b) .036
(c) .001
(d) .723

**Problem 12**. What is the probability that no more than four out of fifteen people used an online travel website when they booked their hotel? Round to the nearest thousandth.

(a) .206
(b) .036
(c) .001
(d) .723

**Problem 13.** Out of fifteen randomly selected people, how many would you expect to use an online travel website to book their hotel? Round down to the nearest whole person.

(a) 9 people
(b) 11 people
(c) 10 people
(d) 12 people

**Problem 14.** You have been assigned to conduct a survey of college and career intentions of high school students at a local high school. You need to start by drawing a simple random sample of 40 students. Which of the following is most likely to produce a simple random sample?

(a) Select the first 40 students to arrive at school in the morning
(b) Select every 10th student entering the school cafeteria until 40 students are selected
(c) Select 10 each of first-year, second-year, third-year, and fourth-year students
(d) Select the first 40 students to enter the library
(e) Select 40 students at random (by using software or a random number table) from the official school roster.

**(Problems 15-16)** Suppose the probability that a person between the ages of 19 and 24 checks their daily horoscope is .12. A survey is then conducted in which 400 people between the ages of 19 and 24 were randomly selected and asked "Do you check your daily horoscope?"

**Problem 15.** Would you be surprised if 63 or more said yes to this question? Why?

(a) Yes, 63 would be an unusually small number of people given the known probability of .12.
(b) No, 63 is within the expected range of people.
(c) Yes, 63 would be an unusually large number of people given the known probability of .12.
(d) Cannot be determined with the given information.

**Problem 16.** If the sample size were 250 instead of 400, would the standard error for the sample proportion of people between the ages of 19 and 24 who check their daily horoscope increase or decrease?

(a) Increase
(b) Decrease
(c) Cannot be determined from the information given

**Problem 17.** The collection of the ages of all the US first ladies when they married is an example of which of the following?

(a) Population
(b) Sample
(c) Parameter
(d) Statistic

**Problem 18.** Suppose that the age of all the US first ladies when they married was recorded. The mean age of US first ladies when they married is an example of which of the following?

(a) Population
(b) Sample
(c) Parameter
(d) Statistic

**Problem 19.** Researchers are interested in learning more about the age of women when they marry for the first time so they survey 500 married or divorced women and ask them how old they were when they first married. The collection of the ages of the 500 women when they first married is an example of which of the following?

(a) Population
(b) Sample
(c) Parameter
(d) Statistic

**Problem 20.** We have calculated a confidence interval based on a sample of size $n$ = 100. Now we want to get a better estimate with a margin of error that is only one-fourth as large. How large does our new sample need to be?

(a) 25
(b) 50
(c) 400
(d) 800

(e) 1600

**Problem 21.** A certain population is approximately Normal. We want to estimate its mean, so we will collect a (random) sample. Which should be true if we use a large sample rather than a small one?

I. The distribution of our sample data will be approximately Normal.
II. The sampling distribution of the sample means will be approximately Normal.
III. The variability of the sample means will be smaller.

(a) I only
(b) II only
(c) III only
(d) II and III only
(e) I, II, and III

**Problem 22.** Which of the following is not an assumption or condition that needs to be checked for the one-proportion $z$-test?

(a) The sample is randomly selected from the population.
(b) The observations within the sample are independent from each other.
(c) The population is Normal.
(d) The sample is large enough to expect at least ten successes and ten failures.
(e) The population size is at least ten times as large as the sample size.

**Problem 23.** We have calculated a 95% confidence interval and would prefer that our next confidence interval has a smaller margin of error without a decrease in confidence. In order to do this, we can:

I. change the $z^*$ or $t^*$ multiplier to a smaller number.
II. take a larger random sample.
III. take a smaller random sample.

(a) I only
(b) II only
(c) III only
(d) I and II only
(e) I and III only

**Problem 24.** Which is true about a 98% confidence interval for a population proportion based on a given random sample?

I. We are 98% confident that the sample proportion is in our interval.
II. There is a 98% chance that our interval contains the population proportion.
III. The interval is wider than a 95% confidence interval for a population proportion would be.

(a) I only
(b) II only
(c) III only
(d) I and III only
(e) II and III only

**Problem 25.** A statistics professor wants to see if more than 80% of her students enjoyed taking her class. At the end of the term, she takes a random sample of students from her large class and asks, in an anonymous survey, if the students enjoyed taking her class. Which set of hypotheses should she test?

(a) $H0 : p < 0.80$ vs. $Ha : p > 0.80$
(b) $H0 : p = 0.80$ vs. $Ha : p > 0.80$
(c) $H0 : p > 0.80$ vs. $Ha : p = 0.80$
(d) $H0 : p = 0.80$ vs. $Ha : p \neq 0.80$
(e) $H0 : p = 0.80$ vs. $Ha : p < 0.80$

**(Problems 26-30)** A sprint duathlon consists of a 5 km run, a 20 km bike ride, followed by another 5 km run. The mean finish time of all participants in a recent large duathlon was 1.67 hours with a standard deviation of 0.25 hours. Suppose a random sample of 30 participants in the 40–44 age group was taken and the mean finishing time was found to be 1.62 hours with a standard deviation of 0.40 hours.

**Problem 26.** In this scenario, the numerical values of 1.62 hours and 0.40 hours are examples of which of the following?

(a) Parameters
(b) Samples
(c) Estimators
(d) Estimates

**Problem 27.** Suppose we were to make a histogram of the finishing times of the 30 participants in the 40–44 age group. Would the histogram be a display of the population distribution, the distribution of a sample, or the sampling distribution of means?

(a) population distribution
(b) distribution of a sample
(c) sampling distribution of means

**Problem 28.** Suppose the process of taking random samples of size 30 from the 40–44 age group is repeated 200 times and a histogram of the 200 sample means is created. Which statement best describes the shape of the histogram?

(a) The histogram will be roughly symmetric.
(b) The histogram will be unimodal.
(c) The histogram will be roughly bell-shaped.
(d) All of the above statements are true.

**Problem 29.** What is the *estimated* standard error for the mean finish time of 30 randomly selected participants in the 40–44 age group? Round to the nearest thousandth.

(a) 0.046
(b) 0.300
(c) 0.073
(d) 0.250
(e) 0.055

**Problem 30.** A random sample of 30 households was selected as part of a study on electricity usage, and the number of kilowatt-hours (kWh) was recorded for each household in the sample. The mean usage was found to be 375 kWh and the standard deviation of the usage was 81 kWh. Provide an expression for calculating a 99% confidence interval for the mean usage in the population.

(a) $375 \pm 2.756 \times \frac{81}{\sqrt{30}}$
(b) $375 \pm 2.33 \times \frac{81}{\sqrt{30}}$
(c) $375 \pm 2.575 \times \sqrt{\frac{81}{30}}$
(d) $375 \pm 2.575 \times \frac{81}{\sqrt{30}}$

(e) $375 \pm 2.33 \times \sqrt{\frac{81}{30}}$

**Problem 31.** Choose the statement that best describes what is meant when we say that the sample mean is unbiased when estimating the population mean.

(a) The sample mean will always equal the population mean.
(b) The standard deviation of the sampling distribution (also called the standard error) and the population standard deviation are equal.
(c) On average, the sample mean is the same as the population mean.
(d) The variation in the sample mean is near zero.
(e) None of the above

**Problem 32.** Suppose that the mean country song length in America is 4.75 minutes with a standard deviation of 1.10 minutes. It is known that song length is not Normally distributed. Find the probability that a single randomly selected song from the population will be less than 4.20 minutes. Round to the nearest thousandth.

(a) 0.006
(b) 0.494
(c) 0.068
(d) The probability cannot be computed because we do not know the distribution of the population.

**Problem 33.** Which of the following statements related to the *t*-distribution is *not* true?

(a) The *t*-distribution is generally bell-shaped, and the shape of the *t*-distribution gets closer to the shape of the Normal distribution as sample size increases.
(b) Since the population standard deviation is usually unknown, the standard error of the sample mean is estimated using the sample standard deviation as an estimator for the population standard deviation. The formula is $SE\text{est} = \frac{s}{\sqrt{n}}$
(c) Like the Normal distribution, the *t*-distribution is symmetric and unimodal.
(d) The population must be *t*-distributed in order to use the *t*-distribution.

**Problem 34.** Suppose a consumer product researcher wanted to find out whether a typical highlighter lasted less than the manufacturer's claim that their highlighters could write continuously for 14 hours. The researcher tested a random sample of 30 highlighters and recorded the number of continuous hours each highlighter wrote before drying up. The summary statistics from this sample are $\bar{x}$ =13.6 hours and $s$

= 1.3 hours. Test the hypothesis that the mean highlighter from this manufacturer writes for less than 14 continuous hours using a significance level of $\alpha = 0.05$.

(a) $z = -1.69$, $p$-value = 0.0455: Reject the null hypothesis and conclude that there is evidence to suggest that the mean highlighter lasts less than 14 hours.
(b) $z = 1.69$, $p$-value = 0.9545: Fail to reject the null hypothesis and conclude that there is not enough evidence to suggest that the mean highlighter lasts less than 14 hours.
(c) $t = -1.685$, $p$-value $> 0.05$: Fail to reject the null hypothesis and conclude that there is not enough evidence to suggest that the mean highlighter lasts less than 14 hours.
(d) $t = -1.685$, $p$-value $< 0.05$: Reject the null hypothesis and conclude that there is evidence to suggest that the mean highlighter lasts less than 14 hours.
(e) There is not enough information given to test the hypothesis.

**(Problems 35-36)** According to the website www.costofwedding.com, the mean cost of flowers for a wedding is $698. Recently, in a random sample of 40 weddings in the US it was found that the average cost of the flowers was $734, with a standard deviation of $102. On the basis of this, a 95% confidence interval for the mean cost of flowers for a wedding is $701 to $767.

**Problem 35** For this scenario, which of the following does *not* describe a condition for a valid confidence interval?
(a) The description states that the sample was randomly selected, so we can assume that the condition that the data must represent a random sample is satisfied.
(b) The sample observations are independent because knowledge about the cost of flowers for any one wedding tells us nothing about the cost of flowers for any other wedding in the sample.
(c) The sample size of 40 is large enough that knowledge about the population distribution is not necessary and the condition that the population be Normally distributed or sample size be larger than 30 is satisfied.
(d) All of the above describe conditions for a valid confidence interval.

**Problem 36.** Choose the statement that is the best interpretation of the confidence interval.
(a) The probability that the flowers at a wedding in the US will cost more than $698 is greater than 5%.
(b) In about 95% of all samples of size 40, the resulting confidence interval will contain the mean cost of flowers at weddings in the US.

(c) We are extremely confident that the mean cost of flowers at a wedding in the US is between $701 and $767.
(d) The probability that flowers at a wedding will cost less than $767 is nearly 100%.

**Problem 37.** A *p*-value indicates

(a) the probability that the null hypothesis is true.
(b) the probability that the alternative hypothesis is true.
(c) the probability of obtaining a test statistic as extreme or more extreme than the observed test statistic, given that the null hypothesis is true.
(d) the probability of obtaining a test statistic as extreme or more extreme than the observed test statistic, given that the alternative hypothesis is true.
(e) None of the above

**(Problem 38-39)** Suppose you have a sample size of $n = 25$, with a sample mean of 60 and a sample standard deviation of 25. Suppose the population mean is thought to be 50. You want to find out whether your sample mean is different from the population mean.

**Problem 38** Do you have a one-tailed or two-tailed alternative hypothesis?

(a) one-tailed
(b) two-tailed

**Problem 39** Which test should you use?

(a) one sample *z*-test
(b) one sample *t*-test
(c) two sample *z*-test
(d) two sample *t*-test

**Problem 40.** If you were to conduct an experiment in which one group of people who consume large amounts of coffee are compared to another group who consume less than one cup per day, what test might be used to test for differences between the two means of the groups?

(a) one sample *z*-test
(b) one sample *t*-test
(c) two sample *z*-test

(d) two sample $t$-test

**Problem 41.** As sample size increases, and all summary statistics remain the same, what will happen to the test statistics for the $z$-test and the $t$-test?

(a) The $z$-statistic will increase in magnitude, the $t$-statistic will not
(b) The $t$-statistic will increase in magnitude, the $z$-statistic will not
(c) They will both increase in magnitude
(d) They will both decrease in magnitude
(e) They will not change

**Problem 42** A researcher tested the null hypothesis that two population means are equal ($H0 : \mu 1 = \mu 2$). A $t$-test produced a $p$-value of 0.01. Assuming that all assumptions of the test have been satisfied, which of the following statements is true?

(a) There is a 1% probability that the result happened by chance.
(b) There is a 1% chance that the null hypothesis is true.
(c) There is a 1% chance of getting a result as extreme or more extreme than the observed one when the null hypothesis is true.
(d) There is a 1% chance that the decision to reject $H0$ is wrong.
(e) There is a 99% chance that the alternative hypothesis is true, given the observed data.

**Problem 43.** Historical data reveals that 47% of all adult women think they do not get enough time for themselves. A recent opinion poll interviews 1025 randomly chosen women and records the sample proportion of women who do not feel that they get enough time for themselves. This statistic will vary from sample to sample if the poll is repeated. Suppose the true population proportion is 0.47. In what range will the middle 68% of all sample results fall for samples of size 1025?

(a) 0.314 to 0.626
(b) −1 to +1
(c) 0.548 to 0.822
(d) 0.454 to 0.486
(e) 0.439 to 0.501

THE END OF THE EXAM.

# Standard Normal Probabilities

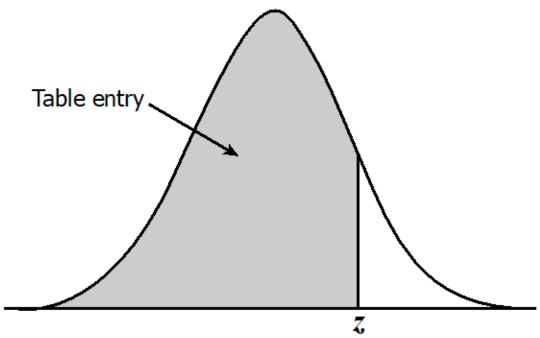



Table entry for $z$ is the area under the standard normal curve to the left of $z$.

| $z$ | .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 | .9279 | .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 |

# Standard Normal Probabilities

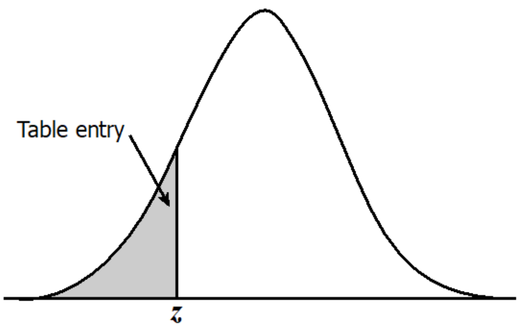
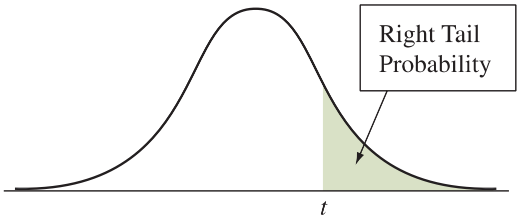



Table entry for $z$ is the area under the standard normal curve to the left of $z$.

| $z$ | .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 | .0018 | .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 | .0351 | .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 | .0721 | .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 | .3483 |
| −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 |




## Table 4: *t* Distribution Critical Values

| | Confidence Level | | | | | |
|---|---|---|---|---|---|---|
| | 80% | 90% | 95% | 98% | 99% | 99.8% |
| | Right-Tail Probability | | | | | |
| *df* | $t_{.100}$ | $t_{.050}$ | $t_{.025}$ | $t_{.010}$ | $t_{.005}$ | $t_{.001}$ |
| 1 | 3.078 | 6.314 | 12.706 | 31.821 | 63.656 | 318.289 |
| 2 | 1.886 | 2.920 | 4.303 | 6.965 | 9.925 | 22.328 |
| 3 | 1.638 | 2.353 | 3.182 | 4.541 | 5.841 | 10.214 |
| 4 | 1.533 | 2.132 | 2.776 | 3.747 | 4.604 | 7.173 |
| 5 | 1.476 | 2.015 | 2.571 | 3.365 | 4.032 | 5.894 |
| 6 | 1.440 | 1.943 | 2.447 | 3.143 | 3.707 | 5.208 |
| 7 | 1.415 | 1.895 | 2.365 | 2.998 | 3.499 | 4.785 |
| 8 | 1.397 | 1.860 | 2.306 | 2.896 | 3.355 | 4.501 |
| 9 | 1.383 | 1.833 | 2.262 | 2.821 | 3.250 | 4.297 |
| 10 | 1.372 | 1.812 | 2.228 | 2.764 | 3.169 | 4.144 |
| 11 | 1.363 | 1.796 | 2.201 | 2.718 | 3.106 | 4.025 |
| 12 | 1.356 | 1.782 | 2.179 | 2.681 | 3.055 | 3.930 |
| 13 | 1.350 | 1.771 | 2.160 | 2.650 | 3.012 | 3.852 |
| 14 | 1.345 | 1.761 | 2.145 | 2.624 | 2.977 | 3.787 |
| 15 | 1.341 | 1.753 | 2.131 | 2.602 | 2.947 | 3.733 |
| 16 | 1.337 | 1.746 | 2.120 | 2.583 | 2.921 | 3.686 |
| 17 | 1.333 | 1.740 | 2.110 | 2.567 | 2.898 | 3.646 |
| 18 | 1.330 | 1.734 | 2.101 | 2.552 | 2.878 | 3.611 |
| 19 | 1.328 | 1.729 | 2.093 | 2.539 | 2.861 | 3.579 |
| 20 | 1.325 | 1.725 | 2.086 | 2.528 | 2.845 | 3.552 |
| 21 | 1.323 | 1.721 | 2.080 | 2.518 | 2.831 | 3.527 |
| 22 | 1.321 | 1.717 | 2.074 | 2.508 | 2.819 | 3.505 |
| 23 | 1.319 | 1.714 | 2.069 | 2.500 | 2.807 | 3.485 |
| 24 | 1.318 | 1.711 | 2.064 | 2.492 | 2.797 | 3.467 |
| 25 | 1.316 | 1.708 | 2.060 | 2.485 | 2.787 | 3.450 |
| 26 | 1.315 | 1.706 | 2.056 | 2.479 | 2.779 | 3.435 |
| 27 | 1.314 | 1.703 | 2.052 | 2.473 | 2.771 | 3.421 |
| 28 | 1.313 | 1.701 | 2.048 | 2.467 | 2.763 | 3.408 |
| 29 | 1.311 | 1.699 | 2.045 | 2.462 | 2.756 | 3.396 |
| 30 | 1.310 | 1.697 | 2.042 | 2.457 | 2.750 | 3.385 |
| 40 | 1.303 | 1.684 | 2.021 | 2.423 | 2.704 | 3.307 |
| 50 | 1.299 | 1.676 | 2.009 | 2.403 | 2.678 | 3.261 |
| 60 | 1.296 | 1.671 | 2.000 | 2.390 | 2.660 | 3.232 |
| 80 | 1.292 | 1.664 | 1.990 | 2.374 | 2.639 | 3.195 |
| 100 | 1.290 | 1.660 | 1.984 | 2.364 | 2.626 | 3.174 |
| ∞ | 1.282 | 1.645 | 1.960 | 2.326 | 2.576 | 3.091 |