STAT 1220 **SPRING 2016**
Common Final Exam **May 5, 2016**

PLEASE PRINT THE FOLLOWING INFORMATION:

Name: ____________________ Instructor: ____________________

Student ID #: ______________ Section/Time: ______________

THIS EXAM HAS TWO PARTS.

PART I.
Part I consists of 30 multiple choice questions. Each correct answer is scored 2 points; each incorrect (or blank) answer is scored 0, so there is no penalty for guessing. You may do calculations on the test paper, but your answers must be marked on the OPSCAN sheet with a soft lead pencil (HB or No. 2 lead). Any question with more than one choice marked will be counted as incorrect. If more than one choice seems correct, choose the one that is most complete or most accurate. Make sure that your name and ID number are written and correctly bubbled on the OPSCAN sheet.

PART II.
Part II consists of 3 free response questions, with values as indicated. You must show all work in the space provided or elsewhere on the exam paper in a place that you clearly indicate. Work on loose sheets will not be graded.

FOR DEPARTMENT USE ONLY:

Part II.

Question	1	2	3
Score			

Part I	Part II	TOTAL

Cumulative Binomial Probability $P(X \leq x)$

n	x	0.05	0.10	0.25	$0.3\bar{3}$	0.50	$0.6\bar{6}$	0.75	0.90	0.95
5	0	0.7738	0.5905	0.2373	0.1317	0.0313	0.0041	0.0010	0.0000	0.0000
	1	0.9774	0.9185	0.6328	0.4609	0.1875	0.0453	0.0156	0.0005	0.0000
	2	0.9988	0.9914	0.8965	0.7901	0.5000	0.2099	0.1035	0.0086	0.0012
	3	1.0000	0.9995	0.9844	0.9547	0.8125	0.5391	0.3672	0.0815	0.0226
	4	1.0000	1.0000	0.9990	0.9959	0.9688	0.8683	0.7627	0.4095	0.2262
20	0	0.3585	0.1216	0.0032	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000
	1	0.7358	0.3917	0.0243	0.0033	0.0000	0.0000	0.0000	0.0000	0.0000
	2	0.9245	0.6769	0.0913	0.0176	0.0002	0.0000	0.0000	0.0000	0.0000
	3	0.9841	0.8670	0.2252	0.0604	0.0013	0.0000	0.0000	0.0000	0.0000
	4	0.9974	0.9568	0.4148	0.1515	0.0059	0.0000	0.0000	0.0000	0.0000
	5	0.9997	0.9887	0.6172	0.2972	0.0207	0.0002	0.0000	0.0000	0.0000
	6	1.0000	0.9976	0.7858	0.4793	0.0577	0.0009	0.0000	0.0000	0.0000
	7	1.0000	0.9996	0.8982	0.6615	0.1316	0.0037	0.0002	0.0000	0.0000
	8	1.0000	0.9999	0.9591	0.8095	0.2517	0.0130	0.0009	0.0000	0.0000
	9	1.0000	1.0000	0.9861	0.9081	0.4119	0.0376	0.0039	0.0000	0.0000
	10	1.0000	1.0000	0.9961	0.9624	0.5881	0.0919	0.0139	0.0000	0.0000
	11	1.0000	1.0000	0.9991	0.9870	0.7483	0.1905	0.0409	0.0001	0.0000
	12	1.0000	1.0000	0.9998	0.9963	0.8684	0.3385	0.1018	0.0004	0.0000
	13	1.0000	1.0000	1.0000	0.9991	0.9423	0.5207	0.2142	0.0024	0.0000
	14	1.0000	1.0000	1.0000	0.9998	0.9793	0.7028	0.3828	0.0113	0.0003
	15	1.0000	1.0000	1.0000	1.0000	0.9941	0.8485	0.5852	0.0432	0.0026
	16	1.0000	1.0000	1.0000	1.0000	0.9987	0.9396	0.7748	0.1330	0.0159
	17	1.0000	1.0000	1.0000	1.0000	0.9998	0.9824	0.9087	0.3231	0.0755
	18	1.0000	1.0000	1.0000	1.0000	1.0000	0.9967	0.9757	0.6083	0.2642
	19	1.0000	1.0000	1.0000	1.0000	1.0000	0.9997	0.9968	0.8784	0.6415

Part I

Problems 1–5 pertain to the data set of 90 measurements represented by the following stem and leaf diagram, in which the stems are the digits in the tens place and leaves are the digits in the ones place.
For these data $\sum x = 6,600$ and $\sum x^2 = 500,940$.

9	0 0 1 2 3 4 4 5 6 7 7 8
8	0 0 1 1 1 2 2 3 4 4 5 5 5 6 6 7 8 8 9 9
7	0 0 0 1 1 1 1 2 2 2 3 3 3 4 4 5 5 6 7 7 7 8 8 8 9 9
6	0 1 1 2 2 3 3 4 4 6 6 6 7 7 8 9
5	0 2 3 5 5 5 6 6 7 8
4	6 6 7 8 9 9

1. The sample mean of this data set is about

   (a) 75.4 (b) 76.8 (c) 73.3 (d) 70.5 (e) 66.0

2. The sample standard deviation of this data set is about

   (a) 190.3 (b) 13.8 (c) 52.8 (d) 11.3 (e) 5.7

3. The sample median is about

   (a) 69 (b) 72.5 (c) 76.5 (d) 73.5 (e) 73

4. The sample range is about

   (a) 52 (b) 90 (c) 64 (d) 13 (e) 98

5. The percentile rank of the measurement 89 is about

   (a) 89 (b) 91 (c) 87 (d) 10 (e) 84

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6. The gestation period for most dog breeds is roughly bell-shaped with mean 63 and standard deviation 1.5 days. The proportion of litters that are born between 60 and 66 days of gestation is about

   (a) 0.95 (b) 0.68 (c) 0.975 (d) 0.50 (e) 0.997

Problems 7 and 8 pertain to the information in the following two-way contingency table, relating the result of a test for a disease and the health with respect to that disease of the person tested:

	diseased	healthy
Test positive	0.043	0.007
Test negative	0.016	0.914
Test inconclusive	0.001	0.019

7. The probability that a randomly selected person is healthy (free of the disease) is about

   (a) 0.940 (b) 0.050 (c) 0.914 (d) 0.933 (e) 0.007

8. The probability that a randomly selected person is healthy (free of the disease), given that the test for the disease is negative, is about

   (a) 1.000 (b) 0.914 (c) 0.972 (d) 0.983 (e) 0.815

Problems 9 and 10 are based on the following information: in a certain region the probability that a randomly selected adult has a credit card is 0.75, that he has a debit card is 0.60, and that he has both is 0.45.

9. The probability that a randomly selected adult has either a credit card or a debit card is about

   (a) 0.15 (b) 0.90 (c) 1.35 (d) 0.45 (e) impossible to tell (insufficient information)

10. The events C: *a randomly selected adult has a credit card* and D: *a randomly selected adult has a debit card* are

    (a) Independent because $P(C) \cdot P(D) = P(C \cap D)$
    (b) Independent because $P(C) \cdot P(D) \neq P(C \cap D)$
    (c) Dependent because $P(C) \cdot P(D) = P(C \cap D)$
    (d) Dependent because $P(C) \cdot P(D) \neq P(C \cap D)$
    (e) impossible to tell if independent or not (insufficient information)

Problems 11–13 pertain to the following probability distribution of the number X of defective items in a randomly selected standard container of 5,000 fasteners. (No container ever has more than 5 defective items.)

x	0	1	2	3	4	5
$P(x)$	p	0.27	0.20	0.06	0.02	0.01

11. The missing entry p is about

    (a) 0.20 (b) 0.00 (c) 0.16 (d) 0.44 (e) 0.32

12. The probability that the container will contain at least two defective fasteners is about

    (a) 0.20 (b) 0.29 (c) 0.14 (d) 0.71 (e) 0.09

13. The average number of defective fasteners per container of 5,000 is about

    (a) 2.5 (b) 1.2 (c) 0.11 (d) 0.98 (e) 1.5

Problems 14 and 15 pertain to the following situation: a woman buys 20 one-dollar lottery tickets per month. The probability of any ticket being a winning ticket is 0.10 or 10%.

14. The probability that in any one month at least three of the tickets that the woman buys are winning tickets is about

    (a) 0.2000 (b) 0.8670 (c) 0.3231 (d) 0.3000 (e) 0.6769

15. The average number of winning tickets that the woman buys each month is about

    (a) 0.2 (b) 1.3 (c) 2.1 (d) 1.5 (e) 2.0

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16. A researcher wishes to estimate the mean level of student loan debt of bachelor's degree students at graduation, with 95% confidence and to within \$500. Assuming that the standard deviation of student loan debt to be about \$3,000, the estimated minimum sample size needed is about

    (a) 98 (b) 139 (c) 10 (d) 67 (c) 195

17. To estimate the effectiveness of a tutoring center its director chose 20 students at random to compare their test scores before using the center with their test scores after using the center. The correct formula to use to construct a confidence interval for the mean difference in scores is

(a) $\bar{x} \pm t_{\alpha/2}(\frac{s}{\sqrt{n}})$ (b) $\bar{d} \pm t_{\alpha/2}\frac{s_d}{\sqrt{n}}$ (c) $(\bar{x}_1 - \bar{x}_2) \pm t_{\alpha/2}\sqrt{s_p^2(\frac{1}{n_1} + \frac{1}{n_2})}$, $s_p^2 = \frac{(n_1-1)s_1^2+(n_2-1)s_2^2}{n_1+n_2-2}$

(d) $(\bar{x}_1 - \bar{x}_2) \pm z_{\alpha/2}\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}$ (e) $(\widehat{p}_1 - \widehat{p}_2) \pm z_{\alpha/2}\sqrt{\frac{\widehat{p}_1\widehat{q}_1}{n_1} + \frac{\widehat{p}_2\widehat{q}_2}{n_2}}$

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18. The yield of wheat on unirrigated land owned by a commercial grower is normally distributed with mean 42.3 bushels and standard deviation 2.4 bushels per acre. The probability that a randomly selected tract of unirrigated land will produce at least 40.5 bushels per acre is about

(a) 0.8361 (b) −0.2266 (c) 0.6628 (d) 0.2266 (e) 0.7734

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19. Letter grades will be assigned in a multi-section course according to the principle that the top and bottom 5% of final scores will be awarded A's and F's, respectively, the next 10% will be awarded B's and D's, and the remaining middle 70% will be awarded C's. If final scores this semester are normally distributed with mean 68.3 and standard deviation 9.9 then the range of scores that will be awarded C's (that is, the interval that is symmetric about 68.3 and has area 0.70 above it) is about

(a) [61.9, 74.7] (b) [63.2, 73.4] (c) [58.0, 78.6] (d) [56.5, 80.1] (e) [60.0, 76.6]

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20. Household incomes in a certain state have mean \$53,550 and standard deviation \$3,750. The probability that the mean of a random sample of 200 households will be within \$500 of the true population mean is about

(a) 0.10 (b) 0.94 (c) 0.88 (d) 0.34 (e) 0.65

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21. Based on past experience an airline food caterer knows that when presented with the choice between meal A and meal B, 58% will select meal A. On a flight seating 175 passengers, the probability that at least 65% will select meal A is about

(a) 0.97 (b) 0.43 (c) 0.15 (d) 0.08 (e) 0.03

22. In a sample of 100 individuals who had retired in 2015, the number of years worked had mean 45.6 and standard deviation 3.8 years. A 90% confidence interval for the mean number of years worked by all individuals who had retired in 2015 is about

(a) $[45.0, 46.2]$ (b) $[45.4, 45.8]$ (c) $[45.1, 46.1]$ (d) $[44.9, 46.3]$ (e) $[44.6, 46.6]$

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23. In a sample of 335 small businesses (those employing at most 50 workers), owners of 81 of them indicated that they wanted to expand their business. A 98% confidence interval for the proportion of all small businesses that intend to expand is about

(a) 0.242 ± 0.060 (b) 0.242 ± 0.046 (c) 0.242 ± 0.038 (d) 0.242 ± 0.054 (c) 0.242 ± 0.073

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24. The estimated ages (in thousands of years) obtained by radiocarbon dating of five artifacts from an archaeological site were:

16.82, 16.30, 15.30, 15.88, 16.54

Assuming that the population of ages of all artifacts is normally distributed, an 90% confidence interval for the mean age of all artifacts from this site is about

(a) 16.17 ± 0.52 (b) 16.17 ± 0.39 (c) 16.17 ± 0.54 (d) 16.17 ± 0.41 (e) 16.17 ± 0.57

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25. A pollster wishes to estimate, with 95% confidence and to within three percentage points, the proportion of all registered voters who favor a flat income tax. Using the fact that one year ago the proportion was 22% or 0.22, the minimum estimated sample size needed to meet these objectives is about

(a) 1,214 (b) 752 (c) 1,068 (d) 516 (e) 733

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26. In a test of hypotheses of the form $H_0 : \mu = 0$ versus $H_a : \mu < 0$ using $\alpha = 0.01$, when the sample size is 16 and the population is normally distributed but of unknown standard deviation the rejection region will be the interval

(a) $(-\infty, -2.947]$ (b) $(-\infty, -2.583]$ (c) $(-\infty, -2.921]$ (d) $(-\infty, -2.602]$ (e) $(-\infty, -2.326]$

27. In a test of hypotheses $H_0 : \mu = -27$ versus $H_a : \mu \neq -27$ in a normally distributed population, the rejection region is the union of intervals $(-\infty, -2.120] \cup [2.120, \infty)$, the value of the sample mean computed from a sample of size 17 is $\bar{x} = -28.5$, and the value of the test statistic is $t = -2.811$. The correct decision and justification are:

(a) Do not reject H_0 because the sample is small.
(b) Do not reject H_0 because -28.5 lies in the rejection region.
(c) Reject H_0 because $\bar{x} = -28.5 \neq -27 = \mu_0$.
(d) Reject H_0 because the test statistic is negative.
(e) Reject H_0 because $-2.811 < -2.120$.

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28. In a test of hypotheses $H_0 : p = 0.38$ vs. $H_a : p \neq 0.38$, at the 5% level of significance, a sample of size 782 produced the test statistic $z = 1.483$. The p-value (the observed significance) of the test is about

(a) 0.050 (b) 0.1388 (c) 1.483 (d) 0.025 (e) 0.0694

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29. The National Association of Colleges and Employers conducted a survey to test whether mean starting salaries of graduates from Region I differed from those of Region II. To do so they recorded the starting salaries of 145 randomly selected graduates from Region I and of 145 randomly selected graduates of Region II. The correct null and alternative hypotheses for this test are

(a) $H_0 : \bar{x}_1 - \bar{x}_2 = 0$ vs. $H_a : \bar{x}_1 - \bar{x}_2 \neq 0$
(b) $H_0 : \mu_d = 0$ vs. $H_a : \mu_d \neq 0$
(c) $H_0 : p_1 - p_2 = 0$ vs. $H_a : p_1 - p_2 \neq 0$
(d) $H_0 : \mu_1 - \mu_2 = 0$ vs. $H_a : \mu_1 - \mu_2 \neq 0$
(e) $H_0 : \mu_1 - \mu_2 = 0$ vs. $H_a : \mu_1 - \mu_2 > 0$

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30. Analysis of data gathered by the U. S. Census Bureau relating level of education x (in years) and unemployment rate y (in percentage points) in a recent year yielded $r = -0.826$, $s_e = 1.224$, and the regression equation $\hat{y} = -1.17x + 26.2$. For each additional year of education the unemployment rate

(a) decreases by about 1.17 percentage points
(b) decreases by about 26.2 percentage points
(c) decreases by about 0.83 percentage points
(d) decreases by about 1.22 percentage points
(e) changes by an amount that cannot be determined from the information given

Part II

1. Historically the mean nurse-to-patient ratio at top rated cancer care facilities has been 1.6. To test whether it is different now with changes that have occurred in the health care system, the ratios at nine facilities were measured, yielding $\bar{x} = 1.93$ and $s = 0.50$. Perform the relevant test at the 1% level of significance, in the following sequence of steps. Assume that the population of nurse-to-patient ratios is normally distributed.

   (a) State the null and alternative hypotheses for the test. [2 points]

   (b) State the formula for the test statistic and compute its value. Justify your answer. [4 points]

   (c) Construct the rejection region and make a decision. [4 points]

   (d) State a conclusion about the mean nurse-to-patient ratio at top rated cancer care facilities, based on the test you performed. [2 points]

2. In order to test whether the presence of fetal stem cells that have crossed the placenta and remained in the woman's body have afforded some level of protection against breast cancer, 54 women with breast cancer and 45 who were cancer-free were examined. Fetal cells were present in 14 of the women with breast cancer and in 25 of the women without. Test the hypothesis that the proportion p_1 of women with breast cancer whose bodies contain fetal stem cells is less than the proportion p_2 of women without breast cancer whose bodies contain fetal stem cells, at the 1% level of significance, in the following series of steps. (The samples are sufficiently large to perform the test.)

   (a) State the null and alternative hypotheses for the test. [2 points]

   (b) State the formula for the test statistic and compute its value. Justify your answer. [4 points]

   (c) Construct the rejection region and make a decision. [4 points]

   (d) State a conclusion about the two population proportions based on the test you performed. [2 points]

   (e) Compute the p-value (the observed significance) of the test. [2 points]

3. The total assets x and shareholders' equity y for a large corporation were recorded in each of six randomly selected recent years, in units of billions of dollars. Summary information is:

$$11.4 \leqslant x \leqslant 37.5 \qquad 5.4 \leqslant y \leqslant 14.8 \qquad \bar{x} = 24.01\bar{6} \qquad \bar{y} = 9.91\bar{6}$$

$$SS_{xx} = 509.728\bar{3} \qquad SS_{xy} = 178.328\bar{3} \qquad SS_{yy} = 62.528\bar{3}$$

(a) Find the proportion of the variability in shareholders' equity that is accounted for by total assets. [4 points]

(b) Find the regression line for predicting y from x. [4 points]

(c) Describe how shareholder equity responds to a $1 billion increase in total assets. [2 points]

(d) For any year in which total assets is $25 billion find the shareholders' equity predicted by the regression equation found in part (b). [2 points]

(e) State whether or not the same computation as in part (d) but for a year in which total assets is $40 billion is valid, and why. [2 points]

STAT 1220 Formula sheet

Descriptive

$$\bar{x} = \frac{\sum x}{n} \qquad s = \sqrt{\frac{\sum x^2 - \frac{1}{n}(\sum x)^2}{n-1}} \qquad z = \frac{x - \bar{x}}{s} \text{ or } z = \frac{x-\mu}{\sigma}$$

Probability

Complements: $P(A^c) = 1 - P(A)$

Additive Rule: $P(A \cup B) = P(A) + P(B) - P(A \cap B)$

Conditional Probability: $P(A|B) = \frac{P(A \cap B)}{P(B)}$

Independence: $P(A \cap B) = P(A) \cdot P(B)$ if and only if A and B are independent events

Discrete Random Variables

$$\mu = E(X) = \sum xP(x) \qquad \sigma = \sqrt{\sum (x-\mu)^2\, P(x)} = \sqrt{\left[\sum x^2\, P(x)\right] - \mu^2}$$

Binomial Random Variable

$$P(x) = \frac{n!}{x!(n-x)!} p^x q^{n-x} \qquad \mu = E(X) = np \qquad \sigma = \sqrt{npq}$$

Sampling Distributions

$$\mu_{\bar{X}} = \mu \qquad \sigma_{\bar{X}} = \frac{\sigma}{\sqrt{n}} \qquad \mu_{\widehat{p}} = p \qquad \sigma_{\widehat{p}} = \sqrt{\frac{p(1-p)}{n}}$$

Sample Sizes for Confidence Intervals

$$n = \frac{(z_{\alpha/2})^2 \sigma^2}{E^2} \quad \text{and} \quad n = \frac{(z_{\alpha/2})^2 \widehat{p}(1-\widehat{p})}{E^2}$$

Inference conditions		Confidence Interval	Test Statistic	df
Inference About a Single Population Mean				
$n \geq 30$	σ known	$\bar{x} \pm z_{\alpha/2}(\frac{\sigma}{\sqrt{n}})$	$Z = \frac{\bar{X}-\mu_0}{\sigma/\sqrt{n}}$	-
	σ unknown	$\bar{x} \pm z_{\alpha/2}(\frac{s}{\sqrt{n}})$	$Z = \frac{\bar{X}-\mu_0}{s/\sqrt{n}}$	-
$n < 30$ and normal population	σ known	$\bar{x} \pm z_{\alpha/2}(\frac{\sigma}{\sqrt{n}})$	$Z = \frac{\bar{X}-\mu_0}{\sigma/\sqrt{n}}$	-
	σ unknown	$\bar{x} \pm t_{\alpha/2}(\frac{s}{\sqrt{n}})$	$T = \frac{\bar{X}-\mu_0}{s/\sqrt{n}}$	$n-1$
Inference About a Single Population Proportion				
$\hat{p} \pm 3\sqrt{\frac{\hat{p}(1-\hat{p})}{n}} \in [0,1]$		$\hat{p} \pm z_{\alpha/2}\sqrt{\frac{\hat{p}(1-\hat{p})}{n}}$	$Z = \frac{\hat{p}-p_0}{\sqrt{\frac{p_0(1-p_0)}{n}}}$	-
Inference About Two Population Means				
independent samples	$n_1 \geq 30$ and $n_2 \geq 30$	$(\bar{x}_1 - \bar{x}_2) \pm z_{\alpha/2}\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}$	$Z = \frac{(\bar{x}_1-\bar{x}_2)-D_0}{\sqrt{\frac{s_1^2}{n_1}+\frac{s_2^2}{n_2}}}$	-
	$n_1 < 30$ or $n_2 < 30$, σ_1 and σ_2 unknown but assumed equal, normal populations	$(\bar{x}_1 - \bar{x}_2) \pm t_{\alpha/2}\sqrt{s_p^2(\frac{1}{n_1} + \frac{1}{n_2})}$; $s_p^2 = \frac{(n_1-1)s_1^2+(n_2-1)s_2^2}{n_1+n_2-2}$	$T = \frac{(\bar{x}_1-\bar{x}_2)-D_0}{\sqrt{s_p^2(\frac{1}{n_1}+\frac{1}{n_2})}}$	$n_1 + n_2 - 2$
paired samples, normal population of differences		$\bar{d} \pm t_{\alpha/2}\frac{s_d}{\sqrt{n}}$	$T = \frac{\bar{d}-D_0}{s_d/\sqrt{n}}$	$n-1$
Inference About Two Population Proportions				
$\hat{p}_j \pm 3\sqrt{\frac{\hat{p}_j(1-\hat{p}_j)}{n_j}} \in [0,1]$, $j = 1,2$		$(\hat{p}_1 - \hat{p}_2) \pm z_{\alpha/2}\sqrt{\frac{\hat{p}_1\hat{q}_1}{n_1} + \frac{\hat{p}_2\hat{q}_2}{n_2}}$	$Z = \frac{(\hat{p}_1-\hat{p}_2)-D_0}{\sqrt{\frac{\hat{p}_1\hat{q}_1}{n_1}+\frac{\hat{p}_2\hat{q}_2}{n_2}}}$	-

Correlation and Regression

$$SS_{xx} = \sum x^2 - \frac{1}{n}\left(\sum x\right)^2 \qquad SS_{xy} = \sum xy - \frac{1}{n}\left(\sum x\right)\left(\sum y\right) \qquad SS_{yy} = \sum y^2 - \frac{1}{n}\left(\sum y\right)^2$$

$$r = \frac{SS_{xy}}{\sqrt{SS_{xx} \cdot SS_{yy}}} \qquad \hat{y} = \hat{\beta}_1 x + \hat{\beta}_0 \quad \text{where} \quad \hat{\beta}_1 = \frac{SS_{xy}}{SS_{xx}} \quad \text{and} \quad \hat{\beta}_0 = \bar{y} - \hat{\beta}_1\bar{x}$$

$$SSE = SS_{yy} - \hat{\beta}_1 SS_{xy} \qquad s_\varepsilon = \sqrt{\frac{SSE}{n-2}} \qquad r^2 = \frac{SS_{yy}-SSE}{SS_{yy}} = \frac{SS_{xy}^2}{SS_{xx}SS_{yy}} = \hat{\beta}_1\frac{SS_{xy}}{SS_{yy}}.$$

$100(1-\alpha)\%$ confidence interval for β_1:

$$\hat{\beta}_1 \pm t_{\alpha/2}\frac{s_\varepsilon}{\sqrt{SS_{xx}}} \qquad (df = n-2)$$

Test statistic for β_1:

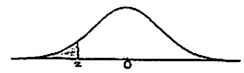
$$T = \frac{\hat{\beta}_1 - B_0}{s_\varepsilon/\sqrt{SS_{xx}}} \qquad (df = n-2)$$

$100(1-\alpha)\%$ confidence interval for the mean value of y at $x = x_p$:

$$\hat{y}_p \pm t_{\alpha/2}\, s_\varepsilon\sqrt{\frac{1}{n} + \frac{(x_p-\bar{x})^2}{SS_{xx}}} \qquad (df = n-2)$$

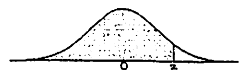
$100(1-\alpha)\%$ prediction interval for an individual new value of y at $x = x_p$:

$$\hat{y}_p \pm t_{\alpha/2}\, s_\varepsilon\sqrt{1 + \frac{1}{n} + \frac{(x_p-\bar{x})^2}{SS_{xx}}} \qquad (df = n-2)$$



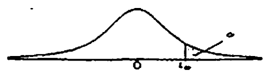
Cumulative Normal Probability $P(Z \leq z)$

z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
−3.9	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
−3.8	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
−3.7	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
−3.6	0.0002	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
−3.5	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
−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



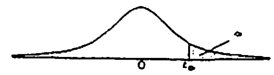
Cumulative Normal Probability $P(Z \leq z)$

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	0.8304	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
3.5	0.9998	0.9998	0.9998	0.9998	0.9998	0.9998	0.9998	0.9998	0.9998	0.9998
3.6	0.9998	0.9998	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999
3.7	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999
3.8	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999
3.9	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000



Critical Values of t

df	$t_{0.200}$	$t_{0.100}$	$t_{0.050}$	$t_{0.025}$	$t_{0.010}$	$t_{0.005}$	$t_{0.0025}$	$t_{0.001}$	$t_{0.0005}$
1	1.376	3.078	6.314	12.706	31.821	63.657	127.321	318.309	636.619
2	1.061	1.886	2.920	4.303	6.965	9.925	14.089	22.327	31.599
3	0.978	1.638	2.353	3.182	4.541	5.841	7.453	10.215	12.924
4	0.941	1.533	2.132	2.776	3.747	4.604	5.598	7.173	8.610
5	0.920	1.476	2.015	2.571	3.365	4.032	4.773	5.893	6.869
6	0.906	1.440	1.943	2.447	3.143	3.707	4.317	5.208	5.959
7	0.896	1.415	1.895	2.365	2.998	3.499	4.029	4.785	5.408
8	0.889	1.397	1.860	2.306	2.896	3.355	3.833	4.501	5.041
9	0.883	1.383	1.833	2.262	2.821	3.250	3.690	4.297	4.781
10	0.879	1.372	1.812	2.228	2.764	3.169	3.581	4.144	4.587
11	0.876	1.363	1.796	2.201	2.718	3.106	3.497	4.025	4.437
12	0.873	1.356	1.782	2.179	2.681	3.055	3.428	3.930	4.318
13	0.870	1.350	1.771	2.160	2.650	3.012	3.372	3.852	4.221
14	0.868	1.345	1.761	2.145	2.624	2.977	3.326	3.787	4.140
15	0.866	1.341	1.753	2.131	2.602	2.947	3.286	3.733	4.073
16	0.865	1.337	1.746	2.120	2.583	2.921	3.252	3.686	4.015
17	0.863	1.333	1.740	2.110	2.576	2.898	3.222	3.646	3.965
18	0.862	1.330	1.734	2.101	2.552	2.878	3.197	3.610	3.922
19	0.861	1.328	1.729	2.093	2.539	2.861	3.174	3.579	3.883
20	0.860	1.325	1.725	2.086	2.528	2.845	3.153	3.552	3.850
21	0.859	1.323	1.721	2.080	2.518	2.831	3.135	3.527	3.819
22	0.858	1.321	1.717	2.074	2.508	2.819	3.119	3.505	3.792
23	0.858	1.319	1.714	2.069	2.500	2.807	3.104	3.485	3.768
24	0.857	1.318	1.711	2.064	2.492	2.797	3.091	3.467	3.745
25	0.856	1.316	1.708	2.060	2.485	2.787	3.078	3.450	3.725
26	0.856	1.315	1.706	2.056	2.479	2.779	3.067	3.435	3.707
27	0.855	1.314	1.703	2.052	2.473	2.771	3.057	3.421	3.690
28	0.855	1.313	1.701	2.048	2.467	2.763	3.047	3.408	3.674
29	0.854	1.311	1.699	2.045	2.462	2.756	3.038	3.396	3.659
30	0.854	1.310	1.697	2.042	2.457	2.750	3.030	3.385	3.646
31	0.853	1.309	1.696	2.040	2.453	2.744	3.022	3.375	3.633
32	0.853	1.309	1.694	2.037	2.449	2.738	3.015	3.365	3.622
33	0.853	1.308	1.692	2.035	2.445	2.733	3.008	3.356	3.611
34	0.852	1.307	1.691	2.032	2.441	2.728	3.002	3.348	3.601
35	0.852	1.306	1.690	2.030	2.438	2.724	2.996	3.340	3.591
36	0.852	1.306	1.688	2.028	2.434	2.719	2.990	3.333	3.582
37	0.851	1.305	1.687	2.026	2.431	2.715	2.985	3.326	3.574
38	0.851	1.304	1.686	2.024	2.429	2.712	2.980	3.319	3.566
39	0.851	1.304	1.685	2.023	2.426	2.708	2.976	3.313	3.558
40	0.851	1.303	1.684	2.021	2.423	2.704	2.971	3.307	3.551
41	0.851	1.303	1.683	2.020	2.421	2.701	2.967	3.301	3.544
42	0.851	1.302	1.682	2.018	2.418	2.698	2.963	3.296	3.538
43	0.851	1.302	1.681	2.017	2.416	2.695	2.959	3.291	3.532
44	8.850	1.301	1.680	2.015	2.414	2.692	2.956	3.286	3.526
45	0.850	1.301	1.679	2.014	2.412	2.690	2.952	3.281	3.520
46	0.850	1.300	1.679	2.013	2.410	2.687	2.949	3.277	3.515
47	0.849	1.300	1.678	2.012	2.408	2.685	2.946	3.273	3.510
48	0.849	1.299	1.677	2.011	2.407	2.682	2.943	3.269	3.505
49	0.849	1.299	1.677	2.010	2.405	2.680	2.940	3.265	3.500
50	0.849	1.299	1.676	2.009	2.403	2.678	2.937	3.261	3.496



Critical Values of t

df	$t_{0.200}$	$t_{0.100}$	$t_{0.050}$	$t_{0.025}$	$t_{0.010}$	$t_{0.005}$	$t_{0.0025}$	$t_{0.001}$	$t_{0.0005}$
51	0.849	1.298	1.675	2.008	2.402	2.676	2.934	3.258	3.492
52	0.849	1.298	1.675	2.007	2.400	2.674	2.932	3.255	3.488
53	0.849	1.298	1.674	2.006	2.399	2.672	2.929	3.251	3.484
54	0.848	1.297	1.674	2.005	2.397	2.670	2.927	3.248	3.480
55	0.848	1.297	1.673	2.004	2.396	2.668	2.925	3.245	3.476
56	0.848	1.297	1.673	2.003	2.395	2.667	2.923	3.242	3.473
57	0.848	1.297	1.672	2.002	2.394	2.665	2.920	3.239	3.470
58	0.848	1.296	1.672	2.002	2.392	2.663	2.918	3.237	3.466
59	0.848	1.296	1.671	2.001	2.391	2.662	2.916	3.234	3.463
60	0.848	1.296	1.671	2.000	2.390	2.660	2.915	3.232	3.460
61	0.848	1.296	1.670	2.000	2.389	2.659	2.913	3.229	3.457
62	0.848	1.295	1.670	1.999	2.388	2.657	2.911	3.227	3.454
63	0.847	1.295	1.669	1.998	2.387	2.656	2.909	3.225	3.452
64	0.847	1.295	1.669	1.998	2.386	2.655	2.908	3.223	3.449
65	0.847	1.295	1.669	1.997	2.385	2.654	2.906	3.220	3.447
66	0.847	1.295	1.668	1.997	2.384	2.652	2.904	3.218	3.444
67	0.847	1.294	1.668	1.996	2.383	2.651	2.903	3.216	3.442
68	0.847	1.294	1.668	1.995	2.382	2.650	2.902	3.214	3.439
69	0.847	1.294	1.667	1.995	2.382	2.649	2.900	3.213	3.437
70	0.847	1.294	1.667	1.994	2.381	2.648	2.899	3.211	3.435
71	0.847	1.294	1.667	1.994	2.380	2.647	2.897	3.209	3.433
72	0.847	1.293	1.666	1.993	2.379	2.646	2.896	3.207	3.431
73	0.847	1.293	1.666	1.993	2.379	2.645	2.895	3.206	3.429
74	0.847	1.293	1.666	1.993	2.378	2.644	2.894	3.204	3.427
75	0.846	1.293	1.665	1.992	2.377	2.643	2.892	3.202	3.425
76	0.846	1.293	1.665	1.992	2.376	2.642	2.891	3.201	3.423
77	0.846	1.293	1.665	1.991	2.376	2.641	2.890	3.199	3.421
78	0.846	1.292	1.665	1.991	2.375	2.640	2.889	3.198	3.420
79	0.846	1.292	1.664	1.990	2.374	2.640	2.888	3.197	3.418
80	0.846	1.292	1.664	1.990	2.374	2.639	2.887	3.195	3.416
81	0.846	1.292	1.664	1.990	2.373	2.638	2.886	3.194	3.415
82	0.846	1.292	1.664	1.989	2.373	2.637	2.885	3.193	3.413
83	0.846	1.292	1.663	1.989	2.372	2.636	2.884	3.191	3.412
84	0.846	1.292	1.663	1.989	2.372	2.636	2.883	3.190	3.410
85	0.846	1.292	1.663	1.988	2.371	2.635	2.882	3.189	3.409
86	0.846	1.291	1.663	1.988	2.370	2.634	2.881	3.188	3.407
87	0.846	1.291	1.663	1.988	2.370	2.634	2.880	3.187	3.406
88	0.846	1.291	1.662	1.987	2.369	2.633	2.880	3.185	3.405
89	0.846	1.291	1.662	1.987	2.369	2.632	2.879	3.184	3.403
90	0.846	1.291	1.662	1.987	2.368	2.632	2.878	3.183	3.402
91	0.846	1.291	1.662	1.986	2.368	2.631	2.877	3.182	3.401
92	0.846	1.291	1.662	1.986	2.368	2.630	2.876	3.181	3.399
93	0.846	1.291	1.661	1.986	2.367	2.630	2.876	3.180	3.398
94	0.846	1.291	1.661	1.986	2.367	2.629	2.875	3.179	3.397
95	0.845	1.291	1.661	1.985	2.366	2.629	2.874	3.178	3.396
96	0.845	1.290	1.661	1.985	2.366	2.628	2.873	3.177	3.395
97	0.845	1.290	1.661	1.985	2.365	2.627	2.873	3.176	3.394
98	0.845	1.290	1.661	1.984	2.365	2.627	2.872	3.175	3.393
99	0.845	1.290	1.660	1.984	2.365	2.626	2.871	3.175	3.392
100	0.845	1.290	1.660	1.984	2.364	2.626	2.871	3.174	3.390
∞ [z]	0.842	1.282	1.645	1.960	2.326	2.576	2.807	3.090	3.291