

NAME: _____

VERSION B

Choose the best answer. Do not write letters in the margin or communicate with other students in any way; if you do you will receive a 0. If you have a question note it on your exam and ask for clarification when your exam is returned. In the meantime choose the best answer. Neither the proctors nor Dr. Cox will answer statistics questions during the exam.

Please check each question and possible answers thoroughly as questions at the bottom of a page sometimes run onto the next page. Please verify that your test version and scantron version are the same.

This exam has 25 questions. Cost for turning in exam late: 1st minute is 10 points; 2nd minute is 20 additional points (30 total); 3rd minute is 30 points (60 total) ; 4th minute is 40 points (100 total); 5th minute is 50 points (150 total); 6th minute is 80 points (230 total) and no exams are graded past that point.

As noted in the syllabus entering your student ID incorrectly on your scantron results in a 10 point deduction.

Use the output below to answer the appropriate questions in the exam. Be sure to check which table the question references.

ANOVA Table 1

| | SS | DF | MS | F | p |
|---------|----------|----|---------|--------|-----------|
| Between | 1234.25 | 3 | 411.417 | 16.053 | 0.0000003 |
| Within | 1127.667 | 44 | 25.629 | | |

Here is regression output from a model where screen size (in diagonal inches) is the independent variable and battery life in hours is the dependent variable. The data are from a random sample of laptops (source, Donnelly 2015).

Regression Table 2

| Regression Statistics | |
|-----------------------|-----------|
| R Square | 0.2478041 |
| Adjusted R Square | 0.1224381 |
| Standard Error | 0.3988209 |
| Observations | 8 |

ANOVA

| | SS | DF | MS | F | p |
|------------|-------|----|-------|-------|-----------|
| Regression | 0.314 | 1 | 0.314 | 1.977 | 0.2093591 |
| Residual | 0.954 | 6 | 0.159 | | |

| | coefficients | standard error | t stat | p-value |
|----------------------------------|--------------|----------------|----------|---------|
| intercept | 5.4715834 | 1.1355027 | 4.81864 | 0.00294 |
| screen size (in diagonal inches) | ?? | 0.0808405 | -1.40593 | 0.20936 |

1. You are going to test the following hypothesis, $H_0 : \mu = 25$ at the .05 level of significance. The report from the statisticians shows that the p-value for this test is .121.
 - (a) You fail to reject the null hypothesis for the one tailed version of the test only.
 - (b) You reject the null hypothesis.
 - (c) You fail to reject the null hypothesis.
 - (d) None of the above.

2. Consider the regression output in Table 2. What is the estimated change in battery life in hours associated with a 1 unit increase in screen size (in diagonal inches) ?
 - (a) -0.1136562
 - (b) -0.0874279
 - (c) 0.3988209
 - (d) 1.977
 - (e) -0.162366

3. Consider the regression output in Table 2. What is the estimated variance of the error term?
 - (a) 0.1994104
 - (b) 0.3988209
 - (c) 1.977
 - (d) 0.1590581

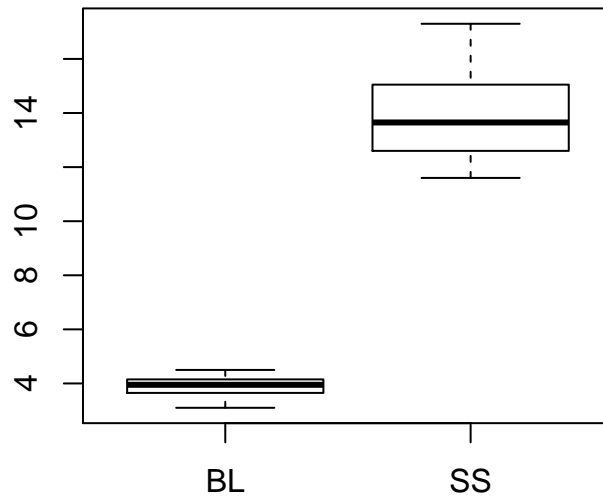
4. Consider the regression output in Table 2. What is the percentage of variation in battery life in hours that can be explained by the variation in screen size (in diagonal inches)?
 - (a) 24.7804124%
 - (b) 12.2438144%
 - (c) -23.7804124%
 - (d) 29.7364948%

5. Consider the regression output in Table 2. What is the predicted or estimated battery life in hours when screen size (in diagonal inches) is 15 inches?
 - (a) 3.7667403

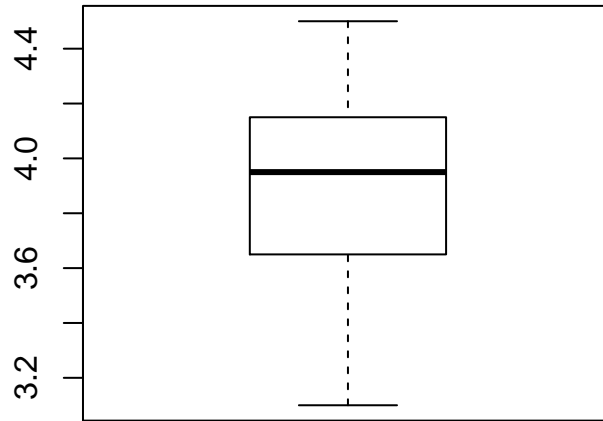
- (b) 3.6871809
 - (c) 4.1077089
 - (d) 3.6530841
 - (e) 3.8008371
6. Consider the regression output in Table 2. Suppose you want to test the hypothesis that screen size (in diagonal inches) reduces battery life by 15 minutes per additional inch, i.e. $H_0 : \beta_1 = -.25$ (15 minutes is .25 of an hour). What is the test statistic for this hypothesis?
- (a) -2.1925524
 - (b) 1.1806051
 - (c) -1.4059323
 - (d) 1.6865788
 - (e) -0.6746315
7. Consider the regression output in Table 2. Suppose you want to test the hypothesis that screen size (in diagonal inches) has no impact on battery life in hours, i.e. $H_0 : \beta_1 = 0$. What is your conclusion for this hypothesis test? (Use $\alpha = .05$.)
- (a) This is inconclusive unless we know whether it is a right tail or a left tail test.
 - (b) This cannot be determined without the appropriate df.
 - (c) reject the null
 - (d) fail to reject
8. Suppose you see that all values of your independent variable are the same. You use this independent variable in your simple regression. Choose the most correct statement below.
- (a) Your intercept term will be zero and the coefficient on your independent variable will be the average of your dependent variable.
 - (b) The R square value will be 0.
 - (c) This cannot happen unless you have fewer observations for the independent variable than for the dependent variable.
 - (d) The sum of squares due to regression will be 0.
 - (e) B and C are correct.
9. What is the median for the following data set? 1, 1.5, 2, 2.5, 3, 3.5, 4, 5, 6.

- (a) 3.
- (b) 3.5.
- (c) 4.
- (d) 4.5.
- (e) none of the above.

10. Consider the graph below. Choose the best answer below



- (a) The mean for BL is greater than the mean for SS.
 - (b) The graph clearly shows that the coefficient of variation for BL is smaller than the coefficient of variation for SS.
 - (c) The interquartile range for BL is larger than the interquartile range of SS.
 - (d) The graph clearly shows that the mean of SS is larger than the median of SS.
 - (e) None of the above.
11. The graph(s) shown here is/are



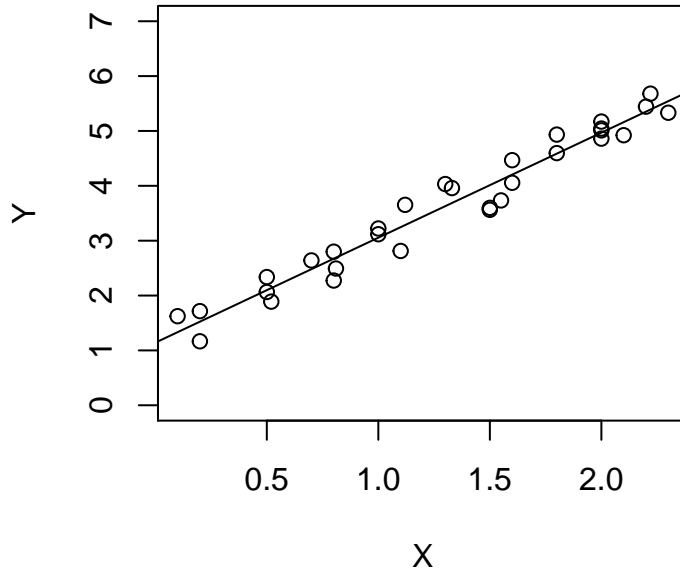
- (a) scatter plots
 - (b) histograms
 - (c) stem and leaf displays
 - (d) box and whiskers plots
12. The probability that a z value is less than 0.46 is
- (a) 0.6483984
 - (b) 0.8314724
 - (c) 0.6772419
 - (d) 0.4540693
 - (e) 0.4840466
13. Consult Table 1. From the table you can conclude that the total sum of squares is
- (a) -106.5833333
 - (b) 1180.9583333

- (c) 1127.6666667
 - (d) 1687.0833333
 - (e) 2361.9166667
14. Consult Table 1. From the table you can conclude that the total number of observations used in this analysis/experiment was?
- (a) 3
 - (b) 5
 - (c) 44
 - (d) 48
 - (e) 46
15. Consult Table 1. From the table what can you conclude concerning the null hypothesis?
- (a) fail to reject
 - (b) reject the null
 - (c) cannot be determined
 - (d) depends on the number of observations.
16. Consult Table 1. What is the test statistic?
- (a) 16.0529116.
 - (b) 25.6287879.
 - (c) 0.0000003.
 - (d) 8.0264558.
 - (e) 411.4166667.
17. Consult Table 1. What is the critical value for a test at the .05 level?
- (a) 3.05
 - (b) 3.59
 - (c) 4.26
 - (d) 1.86
 - (e) 2.82

18. Suppose that you are conducting an ANOVA, with $\alpha = .05$, and you find that the overall variance is 100 and the groupwise variances are 0, 0, .5 and .1 and all groups have 10 of observations. (Note the groupwise variance is the variance of a specific group so that group 3 has a variance of .5.)
- (a) This will lead to a small F statistic and you will fail to reject the null hypothesis.
 - (b) This will lead to a large F statistic and you will reject the null hypothesis.
 - (c) It is impossible to tell anything from this since we do not know the number of overall observations.
 - (d) We can find the number of overall observations but we cannot find the F statistic given this information.
 - (e) None of the above.
19. Suppose that the number of homework assignments a professor gives follows a Poisson distribution with a mean of 13. What is the probability of drawing a professor that gives exactly 9 assignments?
- (a) 0.102087
 - (b) 0.066054
 - (c) 0.0324072
 - (d) 0.0873644
 - (e) 0.0473442
20. Suppose that you collect data on apartment prices in Tempe. You look at 44 different apartments and find a mean of 736 and a standard deviation of 171.4. Construct a 95% confidence interval for the mean apartment price. The interval is
- (a) [687.8896371, 784.1103629]
 - (b) [677.8896371, 794.1103629]
 - (c) [683.8896371, 788.1103629]
 - (d) [615.5006734, 709.2993266]
21. Suppose that you collect data on apartment prices in Tempe. You look at 44 different apartments and find a mean of 736 and a standard deviation of 171.4. Test the hypothesis, $H_0 : \mu = 641$ at the .05 level of significance.
- (a) the test statistic is 3.6765386 so we reject the null
 - (b) the test statistic is 4.1541924 so we fail to reject

- (c) the test statistic is 3.6765386 so we fail to reject
 - (d) the test statistic is 3.1288847 so we reject the null
22. Suppose you have a random variable that is exponentially distributed with a mean of 18. What is the probability of observing a random variable drawn from this distribution with a value of less than 20?
- (a) 0.7364029
 - (b) 0.670807
 - (c) 0.5888877
 - (d) 0.891632
23. If you are conducting ANOVA and you find an F statistic that is less than 1 then this proves that the null hypothesis is true.
- (a) True.
 - (b) False.
24. The following graph shows various pairs of x and y values. Suppose y is the dependent variable in a regression and x is the independent variable. Choose the best option below.

x and y together



- (a) The regression results will show an intercept of about 1 and an estimated slope of about 2.
- (b) The regression results will show an intercept of about 0 and an estimated slope of about 2.
- (c) The regression results will show an intercept of about 5 and an estimated slope of about -2.
- (d) The regression results will show an intercept of about 1 and an estimated slope of about 1.
- (e) The regression results cannot be determined but because X varies so much in the graph we know that R^2 will be relatively small.

25. Suppose that the total sum of squares is 400 and $SSR=300$. The R^2 is

- (a) .25.
- (b) .75.
- (c) 1.33
- (d) 100.

t Distribution

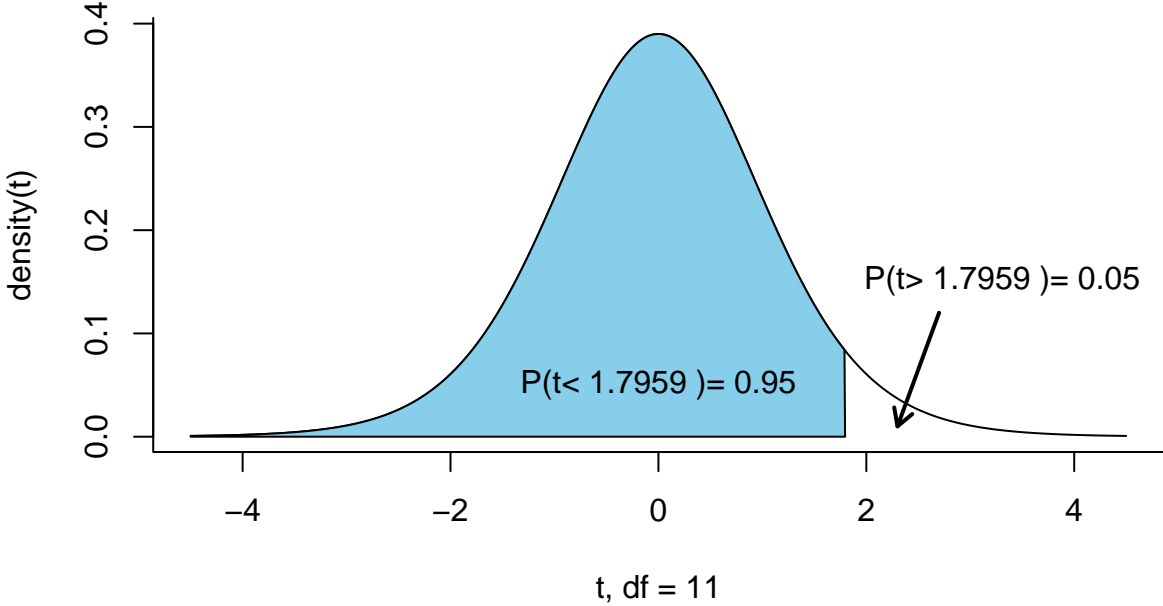


Table of t values. Degrees of Freedom are in the “df” column and *right tail* probabilities are in the top row. Example: for $df=11$ and $P(t > 2.7181) = .01$.

| df | Right tail probability | | | | |
|-----------|------------------------|--------|---------|---------------|---------|
| | 0.1 | 0.05 | 0.025 | 0.01 | 0.005 |
| 1 | 3.0777 | 6.3138 | 12.7062 | 31.8205 | 63.6567 |
| 2 | 1.8856 | 2.92 | 4.3027 | 6.9646 | 9.9248 |
| 3 | 1.6377 | 2.3534 | 3.1824 | 4.5407 | 5.8409 |
| 4 | 1.5332 | 2.1318 | 2.7764 | 3.7469 | 4.6041 |
| 5 | 1.4759 | 2.015 | 2.5706 | 3.3649 | 4.0321 |
| 6 | 1.4398 | 1.9432 | 2.4469 | 3.1427 | 3.7074 |
| 7 | 1.4149 | 1.8946 | 2.3646 | 2.998 | 3.4995 |
| 8 | 1.3968 | 1.8595 | 2.306 | 2.8965 | 3.3554 |
| 9 | 1.383 | 1.8331 | 2.2622 | 2.8214 | 3.2498 |
| 10 | 1.3722 | 1.8125 | 2.2281 | 2.7638 | 3.1693 |
| 11 | 1.3634 | 1.7959 | 2.201 | 2.7181 | 3.1058 |
| 12 | 1.3562 | 1.7823 | 2.1788 | 2.681 | 3.0545 |
| 13 | 1.3502 | 1.7709 | 2.1604 | 2.6503 | 3.0123 |
| 14 | 1.345 | 1.7613 | 2.1448 | 2.6245 | 2.9768 |
| 15 | 1.3406 | 1.7531 | 2.1314 | 2.6025 | 2.9467 |
| 16 | 1.3368 | 1.7459 | 2.1199 | 2.5835 | 2.9208 |
| 17 | 1.3334 | 1.7396 | 2.1098 | 2.5669 | 2.8982 |
| 18 | 1.3304 | 1.7341 | 2.1009 | 2.5524 | 2.8784 |
| 19 | 1.3277 | 1.7291 | 2.093 | 2.5395 | 2.8609 |
| 20 | 1.3253 | 1.7247 | 2.086 | 2.528 | 2.8453 |

| Table of t values continued . For values not on table approximate based on available values. | | | | | |
|---|------------------------|--------|--------|--------|--------|
| | Right tail probability | | | | |
| df | 0.1 | 0.05 | 0.025 | 0.01 | 0.005 |
| 21 | 1.3232 | 1.7207 | 2.0796 | 2.5176 | 2.8314 |
| 22 | 1.3212 | 1.7171 | 2.0739 | 2.5083 | 2.8188 |
| 23 | 1.3195 | 1.7139 | 2.0687 | 2.4999 | 2.8073 |
| 24 | 1.3178 | 1.7109 | 2.0639 | 2.4922 | 2.7969 |
| 25 | 1.3163 | 1.7081 | 2.0595 | 2.4851 | 2.7874 |
| 26 | 1.315 | 1.7056 | 2.0555 | 2.4786 | 2.7787 |
| 27 | 1.3137 | 1.7033 | 2.0518 | 2.4727 | 2.7707 |
| 28 | 1.3125 | 1.7011 | 2.0484 | 2.4671 | 2.7633 |
| 29 | 1.3114 | 1.6991 | 2.0452 | 2.462 | 2.7564 |
| 30 | 1.3104 | 1.6973 | 2.0423 | 2.4573 | 2.75 |
| 31 | 1.3095 | 1.6955 | 2.0395 | 2.4528 | 2.744 |
| 32 | 1.3086 | 1.6939 | 2.0369 | 2.4487 | 2.7385 |
| 33 | 1.3077 | 1.6924 | 2.0345 | 2.4448 | 2.7333 |
| 34 | 1.307 | 1.6909 | 2.0322 | 2.4411 | 2.7284 |
| 35 | 1.3062 | 1.6896 | 2.0301 | 2.4377 | 2.7238 |
| 36 | 1.3055 | 1.6883 | 2.0281 | 2.4345 | 2.7195 |
| 37 | 1.3049 | 1.6871 | 2.0262 | 2.4314 | 2.7154 |
| 38 | 1.3042 | 1.686 | 2.0244 | 2.4286 | 2.7116 |
| 39 | 1.3036 | 1.6849 | 2.0227 | 2.4258 | 2.7079 |
| 40 | 1.3031 | 1.6839 | 2.0211 | 2.4233 | 2.7045 |
| 41 | 1.3025 | 1.6829 | 2.0195 | 2.4208 | 2.7012 |
| 42 | 1.302 | 1.682 | 2.0181 | 2.4185 | 2.6981 |
| 43 | 1.3016 | 1.6811 | 2.0167 | 2.4163 | 2.6951 |
| 44 | 1.3011 | 1.6802 | 2.0154 | 2.4141 | 2.6923 |
| 45 | 1.3006 | 1.6794 | 2.0141 | 2.4121 | 2.6896 |
| 46 | 1.3002 | 1.6787 | 2.0129 | 2.4102 | 2.687 |
| 47 | 1.2998 | 1.6779 | 2.0117 | 2.4083 | 2.6846 |
| 48 | 1.2994 | 1.6772 | 2.0106 | 2.4066 | 2.6822 |
| 49 | 1.2991 | 1.6766 | 2.0096 | 2.4049 | 2.68 |
| 50 | 1.2987 | 1.6759 | 2.0086 | 2.4033 | 2.6778 |
| 51 | 1.2984 | 1.6753 | 2.0076 | 2.4017 | 2.6757 |
| 52 | 1.298 | 1.6747 | 2.0066 | 2.4002 | 2.6737 |
| 53 | 1.2977 | 1.6741 | 2.0057 | 2.3988 | 2.6718 |
| 54 | 1.2974 | 1.6736 | 2.0049 | 2.3974 | 2.67 |
| 55 | 1.2971 | 1.673 | 2.004 | 2.3961 | 2.6682 |
| 56 | 1.2969 | 1.6725 | 2.0032 | 2.3948 | 2.6665 |
| 57 | 1.2966 | 1.672 | 2.0025 | 2.3936 | 2.6649 |
| 58 | 1.2963 | 1.6716 | 2.0017 | 2.3924 | 2.6633 |
| 59 | 1.2961 | 1.6711 | 2.001 | 2.3912 | 2.6618 |
| 60 | 1.2958 | 1.6706 | 2.0003 | 2.3901 | 2.6603 |
| 61 | 1.2956 | 1.6702 | 1.9996 | 2.389 | 2.6589 |
| 62 | 1.2954 | 1.6698 | 1.999 | 2.388 | 2.6575 |
| 63 | 1.2951 | 1.6694 | 1.9983 | 2.387 | 2.6561 |
| 64 | 1.2949 | 1.669 | 1.9977 | 2.386 | 2.6549 |
| 65 | 1.2947 | 1.6686 | 1.9971 | 2.3851 | 2.6536 |
| 66 | 1.2945 | 1.6683 | 1.9966 | 2.3842 | 2.6524 |
| 67 | 1.2943 | 1.6679 | 1.996 | 2.3833 | 2.6512 |
| 68 | 1.2941 | 1.6676 | 1.9955 | 2.3824 | 2.6501 |
| 69 | 1.2939 | 1.6672 | 1.9949 | 2.3816 | 2.649 |
| 70 | 1.2938 | 1.6669 | 1.9944 | 2.3808 | 2.6479 |

| Table of t values continued . For values not on table approximate based on available values. | | | | | |
|---|------------------------|--------|--------|--------|--------|
| | Right tail probability | | | | |
| df | 0.1 | 0.05 | 0.025 | 0.01 | 0.005 |
| 71 | 1.2936 | 1.6666 | 1.9939 | 2.38 | 2.6469 |
| 72 | 1.2934 | 1.6663 | 1.9935 | 2.3793 | 2.6459 |
| 73 | 1.2933 | 1.666 | 1.993 | 2.3785 | 2.6449 |
| 74 | 1.2931 | 1.6657 | 1.9925 | 2.3778 | 2.6439 |
| 75 | 1.2929 | 1.6654 | 1.9921 | 2.3771 | 2.643 |
| 76 | 1.2928 | 1.6652 | 1.9917 | 2.3764 | 2.6421 |
| 77 | 1.2926 | 1.6649 | 1.9913 | 2.3758 | 2.6412 |
| 78 | 1.2925 | 1.6646 | 1.9908 | 2.3751 | 2.6403 |
| 79 | 1.2924 | 1.6644 | 1.9905 | 2.3745 | 2.6395 |
| 80 | 1.2922 | 1.6641 | 1.9901 | 2.3739 | 2.6387 |
| 81 | 1.2921 | 1.6639 | 1.9897 | 2.3733 | 2.6379 |
| 82 | 1.292 | 1.6636 | 1.9893 | 2.3727 | 2.6371 |
| 83 | 1.2918 | 1.6634 | 1.989 | 2.3721 | 2.6364 |
| 84 | 1.2917 | 1.6632 | 1.9886 | 2.3716 | 2.6356 |
| 85 | 1.2916 | 1.663 | 1.9883 | 2.371 | 2.6349 |
| 86 | 1.2915 | 1.6628 | 1.9879 | 2.3705 | 2.6342 |
| 87 | 1.2914 | 1.6626 | 1.9876 | 2.37 | 2.6335 |
| 88 | 1.2912 | 1.6624 | 1.9873 | 2.3695 | 2.6329 |
| 89 | 1.2911 | 1.6622 | 1.987 | 2.369 | 2.6322 |
| 90 | 1.291 | 1.662 | 1.9867 | 2.3685 | 2.6316 |
| 91 | 1.2909 | 1.6618 | 1.9864 | 2.368 | 2.6309 |
| 92 | 1.2908 | 1.6616 | 1.9861 | 2.3676 | 2.6303 |
| 93 | 1.2907 | 1.6614 | 1.9858 | 2.3671 | 2.6297 |
| 94 | 1.2906 | 1.6612 | 1.9855 | 2.3667 | 2.6291 |
| 95 | 1.2905 | 1.6611 | 1.9853 | 2.3662 | 2.6286 |
| 96 | 1.2904 | 1.6609 | 1.985 | 2.3658 | 2.628 |
| 97 | 1.2903 | 1.6607 | 1.9847 | 2.3654 | 2.6275 |
| 98 | 1.2902 | 1.6606 | 1.9845 | 2.365 | 2.6269 |
| 99 | 1.2902 | 1.6604 | 1.9842 | 2.3646 | 2.6264 |
| 100 | 1.2901 | 1.6602 | 1.984 | 2.3642 | 2.6259 |
| 120 | 1.2886 | 1.6577 | 1.9799 | 2.3578 | 2.6174 |
| 150 | 1.2872 | 1.6551 | 1.9759 | 2.3515 | 2.609 |
| 200 | 1.2858 | 1.6525 | 1.9719 | 2.3451 | 2.6006 |
| 300 | 1.2844 | 1.6499 | 1.9679 | 2.3388 | 2.5923 |
| 500 | 1.2832 | 1.6479 | 1.9647 | 2.3338 | 2.5857 |
| 1000 | 1.2824 | 1.6464 | 1.9623 | 2.3301 | 2.5808 |
| 10000+ | 1.2816 | 1.645 | 1.9602 | 2.3267 | 2.5763 |

Notes: for values not on the table, e.g. where df are 101 you can either approximate or for homework and test taking in ECN221 you can simply use the previous available value on the table. For example, you have a problem where df=125 and you are looking for a right tail probability of .05 then you can simply go to the row where df=120 and find a value of 1.6577 and use that value. For *left tail* probabilities the t values are the negative of the values in the table since the t distribution is symmetric around 0. For example, for 50 df and a left tail probability of .1 the t value is -1.2987.

Standard Normal, aka z Distribution

| Table of z values and probabilities for the standard normal distribution. z is in the first column plus the top row. Each cell shows $P(X \leq z)$. For example $P(Z \leq 1.04) = .8508$. For $z < 0$ subtract the value from 1, e.g., $P(X \leq -1.04) = 1 - .8508 = .1492$. | | | | | | | | | | |
|--|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| z | 0 | 0.01 | 0.02 | 0.03 | 0.04 | 0.05 | 0.06 | 0.07 | 0.08 | 0.09 |
| 0 | 0.5 | 0.504 | 0.508 | 0.512 | 0.516 | 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 | 0.591 | 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 | 0.648 | 0.6517 |
| 0.4 | 0.6554 | 0.6591 | 0.6628 | 0.6664 | 0.67 | 0.6736 | 0.6772 | 0.6808 | 0.6844 | 0.6879 |
| 0.5 | 0.6915 | 0.695 | 0.6985 | 0.7019 | 0.7054 | 0.7088 | 0.7123 | 0.7157 | 0.719 | 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 | 0.758 | 0.7611 | 0.7642 | 0.7673 | 0.7704 | 0.7734 | 0.7764 | 0.7794 | 0.7823 | 0.7852 |
| 0.8 | 0.7881 | 0.791 | 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 | 0.834 | 0.8365 | 0.8389 |
| 1 | 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 | 0.877 | 0.879 | 0.881 | 0.883 |
| 1.2 | 0.8849 | 0.8869 | 0.8888 | 0.8907 | 0.8925 | 0.8944 | 0.8962 | 0.898 | 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 | 0.937 | 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 | 0.975 | 0.9756 | 0.9761 | 0.9767 |
| 2 | 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 | 0.983 | 0.9834 | 0.9838 | 0.9842 | 0.9846 | 0.985 | 0.9854 | 0.9857 |
| 2.2 | 0.9861 | 0.9864 | 0.9868 | 0.9871 | 0.9875 | 0.9878 | 0.9881 | 0.9884 | 0.9887 | 0.989 |
| 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 | 0.992 | 0.9922 | 0.9925 | 0.9927 | 0.9929 | 0.9931 | 0.9932 | 0.9934 | 0.9936 |
| 2.5 | 0.9938 | 0.994 | 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 | 0.996 | 0.9961 | 0.9962 | 0.9963 | 0.9964 |
| 2.7 | 0.9965 | 0.9966 | 0.9967 | 0.9968 | 0.9969 | 0.997 | 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 | 0.998 | 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 | 0.9987 | 0.9987 | 0.9987 | 0.9988 | 0.9988 | 0.9989 | 0.9989 | 0.9989 | 0.999 | 0.999 |
| 3.1 | 0.999 | 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 |

Table of F values for right tail probabilities of .05. Degrees of freedom for the denominator are in the first column and degrees of freedom for the numerator are in the top row.

| denom. df | numerator df | | | | | | | | | |
|--------------|--------------|-------|---------|---------|---------|---------|---------|--------|---------|---------|
| | 1 | 2 | 3 | 4 | 5 | 7 | 10 | 15 | 50 | 100 |
| 1 | 161.448 | 199.5 | 215.707 | 224.583 | 230.162 | 236.768 | 241.882 | 245.95 | 251.774 | 253.041 |
| 2 | 18.513 | 19 | 19.164 | 19.247 | 19.296 | 19.353 | 19.396 | 19.429 | 19.476 | 19.486 |
| 3 | 10.128 | 9.552 | 9.277 | 9.117 | 9.013 | 8.887 | 8.786 | 8.703 | 8.581 | 8.554 |
| 4 | 7.709 | 6.944 | 6.591 | 6.388 | 6.256 | 6.094 | 5.964 | 5.858 | 5.699 | 5.664 |
| 5 | 6.608 | 5.786 | 5.409 | 5.192 | 5.05 | 4.876 | 4.735 | 4.619 | 4.444 | 4.405 |
| 6 | 5.987 | 5.143 | 4.757 | 4.534 | 4.387 | 4.207 | 4.06 | 3.938 | 3.754 | 3.712 |
| 7 | 5.591 | 4.737 | 4.347 | 4.12 | 3.972 | 3.787 | 3.637 | 3.511 | 3.319 | 3.275 |
| 8 | 5.318 | 4.459 | 4.066 | 3.838 | 3.687 | 3.5 | 3.347 | 3.218 | 3.02 | 2.975 |
| 9 | 5.117 | 4.256 | 3.863 | 3.633 | 3.482 | 3.293 | 3.137 | 3.006 | 2.803 | 2.756 |
| 10 | 4.965 | 4.103 | 3.708 | 3.478 | 3.326 | 3.135 | 2.978 | 2.845 | 2.637 | 2.588 |
| 11 | 4.844 | 3.982 | 3.587 | 3.357 | 3.204 | 3.012 | 2.854 | 2.719 | 2.507 | 2.457 |
| 12 | 4.747 | 3.885 | 3.49 | 3.259 | 3.106 | 2.913 | 2.753 | 2.617 | 2.401 | 2.35 |
| 13 | 4.667 | 3.806 | 3.411 | 3.179 | 3.025 | 2.832 | 2.671 | 2.533 | 2.314 | 2.261 |
| 14 | 4.6 | 3.739 | 3.344 | 3.112 | 2.958 | 2.764 | 2.602 | 2.463 | 2.241 | 2.187 |
| 15 | 4.543 | 3.682 | 3.287 | 3.056 | 2.901 | 2.707 | 2.544 | 2.403 | 2.178 | 2.123 |
| 16 | 4.494 | 3.634 | 3.239 | 3.007 | 2.852 | 2.657 | 2.494 | 2.352 | 2.124 | 2.068 |
| 17 | 4.451 | 3.592 | 3.197 | 2.965 | 2.81 | 2.614 | 2.45 | 2.308 | 2.077 | 2.02 |
| 18 | 4.414 | 3.555 | 3.16 | 2.928 | 2.773 | 2.577 | 2.412 | 2.269 | 2.035 | 1.978 |
| 19 | 4.381 | 3.522 | 3.127 | 2.895 | 2.74 | 2.544 | 2.378 | 2.234 | 1.999 | 1.94 |
| 20 | 4.351 | 3.493 | 3.098 | 2.866 | 2.711 | 2.514 | 2.348 | 2.203 | 1.966 | 1.907 |
| 21 | 4.325 | 3.467 | 3.072 | 2.84 | 2.685 | 2.488 | 2.321 | 2.176 | 1.936 | 1.876 |
| 22 | 4.301 | 3.443 | 3.049 | 2.817 | 2.661 | 2.464 | 2.297 | 2.151 | 1.909 | 1.849 |
| 23 | 4.279 | 3.422 | 3.028 | 2.796 | 2.64 | 2.442 | 2.275 | 2.128 | 1.885 | 1.823 |
| 24 | 4.26 | 3.403 | 3.009 | 2.776 | 2.621 | 2.423 | 2.255 | 2.108 | 1.863 | 1.8 |
| 25 | 4.242 | 3.385 | 2.991 | 2.759 | 2.603 | 2.405 | 2.236 | 2.089 | 1.842 | 1.779 |
| 26 | 4.225 | 3.369 | 2.975 | 2.743 | 2.587 | 2.388 | 2.22 | 2.072 | 1.823 | 1.76 |
| 27 | 4.21 | 3.354 | 2.96 | 2.728 | 2.572 | 2.373 | 2.204 | 2.056 | 1.806 | 1.742 |
| 28 | 4.196 | 3.34 | 2.947 | 2.714 | 2.558 | 2.359 | 2.19 | 2.041 | 1.79 | 1.725 |
| 29 | 4.183 | 3.328 | 2.934 | 2.701 | 2.545 | 2.346 | 2.177 | 2.027 | 1.775 | 1.71 |
| 30 | 4.171 | 3.316 | 2.922 | 2.69 | 2.534 | 2.334 | 2.165 | 2.015 | 1.761 | 1.695 |
| 35 | 4.121 | 3.267 | 2.874 | 2.641 | 2.485 | 2.285 | 2.114 | 1.963 | 1.703 | 1.635 |
| 40 | 4.085 | 3.232 | 2.839 | 2.606 | 2.449 | 2.249 | 2.077 | 1.924 | 1.66 | 1.589 |
| 50 | 4.034 | 3.183 | 2.79 | 2.557 | 2.4 | 2.199 | 2.026 | 1.871 | 1.599 | 1.525 |
| 60 | 4.001 | 3.15 | 2.758 | 2.525 | 2.368 | 2.167 | 1.993 | 1.836 | 1.559 | 1.481 |
| 80 | 3.96 | 3.111 | 2.719 | 2.486 | 2.329 | 2.126 | 1.951 | 1.793 | 1.508 | 1.426 |
| 100 | 3.936 | 3.087 | 2.696 | 2.463 | 2.305 | 2.103 | 1.927 | 1.768 | 1.477 | 1.392 |
| 1000 | 3.851 | 3.005 | 2.614 | 2.381 | 2.223 | 2.019 | 1.84 | 1.676 | 1.363 | 1.26 |

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| <p>Chapter 3:</p> <p>sample mean: $\bar{x} = \frac{\sum_{i=1}^n x_i}{n}$</p> <p>sample variance: $s^2 = \frac{\sum_{i=1}^n (x_i - \bar{x})^2}{n - 1}$</p> <p>sample standard deviation: $s = \sqrt{s^2}$</p> <p>Coefficient of Variation: $CV = \frac{s}{\bar{x}} (100\%)$</p> <p>sample z-Score: $z = \frac{x_i - \bar{x}}{s}$</p> <p>Interquartile Range: $IQR = Q_3 - Q_1$</p> <p>Sample Covariance: $s_{xy} = \frac{\sum_{i=1}^n (x_i - \bar{x})(y_i - \bar{y})}{n - 1}$</p> <p>Sample Correlation Coefficient: $r_{xy} = s_{xy} / (s_x s_y)$</p> <p>Chapter 4:</p> <p>The complement rule: $P(A) + P(A^c) = 1$</p> <p>addition rule: $P(A \text{ or } B) = P(A) + P(B) - P(A \text{ and } B)$</p> <p>conditional probability: $P(A B) = \frac{P(A \text{ and } B)}{P(B)}$</p> <p>Bayes' Theorem</p> $P(A_i B) = \frac{P(A_i)P(B A_i)}{P(A_1)P(B A_1) + P(A_2)P(B A_2) + \dots + P(A_n)P(B A_n)}$ <p>Combinations: ${}_n C_x = \frac{n!}{(n-x)!x!}$</p> <p>Chapter 5:</p> <p>Expected Value and mean of a Discrete Probability Distribution:</p> $E(x) = \mu = \sum_{i=1}^n x_i P(x_i)$ <p>Variance of a Discrete Probability Distribution:</p> $\sigma^2 = \sum_{i=1}^n (x_i - \mu)^2 P(x_i)$ | <p>Chapter 5 continued:</p> <p>Binomial Probability Dist.: $P(x, n) = \frac{n!}{(n-x)!x!} p^x (q)^{(n-x)}$</p> <p>Mean of a Binomial Distribution: $\mu = np$</p> <p>Standard Dev. of a Binomial Distribution: $\sigma = \sqrt{npq}$</p> <p>Poisson Probability Distribution: $P(x) = \frac{\lambda^x e^{-\lambda}}{x!}$</p> <p>Chapter 6:</p> <p>Normal PDF: $f(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-(1/2)[(x-\mu)/\sigma]^2}$</p> <p>the z-score: $z = \frac{x - \mu}{\sigma}$</p> <p>Exponential PDF: $f(x) = \lambda e^{-\lambda x}$</p> <p>Exponential CDF: $P(x \leq a) = 1 - e^{-a\lambda}$</p> <p>Standard Dev. of Exponential Dist.: $\sigma = \mu = \frac{1}{\lambda}$</p> <p>Continuous Uniform PDF</p> $f(x) = \begin{cases} \frac{1}{b-a} & \text{if } a \leq x \leq b \\ 0 & \text{otherwise} \end{cases}$ <p>Uniform CDF: $P(x_1 \leq x \leq x_2) = \frac{x_2 - x_1}{b - a}$</p> <p>mean of the continuous uniform dist.: $\mu = \frac{a+b}{2}$</p> <p>standard dev. of the continuous uniform dist.: $\sigma = \frac{b-a}{\sqrt{12}}$</p> <p>Chapter 7:</p> <p>standard error of the mean: $\sigma_{\bar{x}} = \frac{\sigma}{\sqrt{n}}$</p> <p>z-score for the mean: $z_{\bar{x}} = \frac{\bar{x} - \mu_{\bar{x}}}{\sigma_{\bar{x}}}$</p> | <p>Chapter 7 continued:</p> <p>sample proportion: $\bar{p} = \frac{x}{n}$</p> <p>standard error of the proportion: $\sigma_{\bar{p}} = \sqrt{\frac{p(1-p)}{n}}$</p> <p>Chapter 8:</p> <p>Confidence Interval for the mean (σ known):</p> $\bar{x} \pm z_{\alpha/2} \sigma_{\bar{x}}$ <p>margin of error for a CI for the mean: $ME_{\bar{x}} = z_{\alpha/2} \sigma_{\bar{x}}$</p> <p>approximate standard error of the mean: $\hat{\sigma}_{\bar{x}} = \frac{s}{\sqrt{n}}$</p> <p>Confidence Interval for the mean (σ unknown):</p> $\bar{x} \pm t_{\alpha/2} \hat{\sigma}_{\bar{x}}$ <p>Sample Size needed to Estimate a population mean</p> $n = \frac{(z_{\alpha/2})^2 \sigma^2}{(ME_{\bar{x}})^2}$ <p>Sample Size needed to Estimate the population proportion</p> $n = \frac{(z_{\alpha/2})^2 \bar{p}(1-\bar{p})}{(ME_p)^2}$ <p>Chapter 9:</p> <p>the z-test statistic for a hypothesis test for the population mean (when σ is known)</p> $z_{\bar{x}} = \frac{\bar{x} - \mu_{H_0}}{\sigma / \sqrt{n}}$ <p>the t-test statistic for a hypothesis test for the population mean (when σ is unknown)</p> $t_{\bar{x}} = \frac{\bar{x} - \mu_{H_0}}{s / \sqrt{n}}$ |
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| <p>Chapter 10: the mean of the sampling distribution for the difference in means:</p> $\mu_{\bar{x}_1 - \bar{x}_2} = \mu_{\bar{x}_1} - \mu_{\bar{x}_2}$ <p>the standard error of the difference between two means:</p> $\sigma_{\bar{x}_1 - \bar{x}_2} = \sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}$ <p>the z-test statistic for a hypothesis test for the difference between two means (σ_1 and σ_2 known)</p> $z_{\bar{x}} = \frac{(\bar{x}_1 - \bar{x}_2) - (\mu_1 - \mu_2)H_0}{\sigma_{\bar{x}_1 - \bar{x}_2}}$ <p>the t-test statistic for a hypothesis test for the difference between two means (σ_1 and σ_2 unknown but equal)</p> $t_{\bar{x}} = \frac{(\bar{x}_1 - \bar{x}_2) - (\mu_1 - \mu_2)H_0}{\sqrt{s_p^2 \left(\frac{1}{n_1} + \frac{1}{n_2} \right)}}$ <p>pooled variance: $s_p^2 = \frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2}{(n_1 - 1) + (n_2 - 1)}$</p> <p>the t-test statistic for a hypothesis test for the difference between two means (σ_1 and σ_2 unknown and unequal)</p> $t_{\bar{x}} = \frac{(\bar{x}_1 - \bar{x}_2) - (\mu_1 - \mu_2)H_0}{\sqrt{\left(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2} \right)}}$ <p>Confidence Interval for the difference between the means of two independent populations (σ_1 and σ_2 unknown but equal)</p> $(\bar{x}_1 - \bar{x}_2) \pm t_{\alpha/2} \sqrt{\frac{s_p^2}{n_1} + \frac{s_p^2}{n_2}}$ <p>the matched-pair difference: $d = x_1 - x_2$</p> <p>the mean of matched-pair difference: $\bar{d} = \frac{\sum_{i=1}^n d_i}{n}$</p> <p>the standard deviation of the matched-pair differences</p> $s_d = \sqrt{\frac{\sum_{i=1}^n (d_i - \bar{d})^2}{n - 1}}$ <p>the t-Test Statistic for a Matched-Pair hypothesis test for the mean</p> $t_{\bar{x}} = \frac{\bar{d} - (\mu_d)H_0}{s_d / \sqrt{n}}$ | <p>Chapter 11:</p> <p>the total sum of squares (SST): $SST = \sum_{j=1}^k \sum_{i=1}^{n_j} (x_{ij} - \bar{x})^2$</p> <p>the mean square total (MST): $MST = \frac{SST}{n_T - 1}$</p> <p>the partitioning of the Total Sum of Squares (SST) for a One-Way ANOVA: $SST = SSB + SSW$.</p> <p>sum of squares between (SSB): $SSB = \sum_{j=1}^k n_j (\bar{x}_j - \bar{x})^2$</p> <p>the mean square between (MSB): $MSB = \frac{SSB}{k - 1}$</p> <p>sum of squares within (SSW): $SSW = \sum_{j=1}^k \sum_{i=1}^{n_j} (x_{ij} - \bar{x}_j)^2$</p> <p>the mean square within (MSW): $MSW = \frac{SSW}{n_T - k}$</p> <p>the F-test statistic for One-Way ANOVA: $F_{\bar{x}} = \frac{MSB}{MSW}$</p> <p>Tukey-Kramer critical range:</p> $CR_{ij} = Q_{\alpha} \sqrt{\frac{MSW}{2} \left(\frac{1}{n_i} + \frac{1}{n_j} \right)}$ <p>Chapter 14: simple linear regression model for a population $y_i = \beta_0 + \beta_1 x_i + \epsilon_i$</p> $\hat{y} = b_0 + b_1 x \quad \epsilon_i = y_i - \hat{y}_i$ <p>sum of squares error: $SSE = \sum_{i=1}^n (y_i - \hat{y}_i)^2$</p> <p>total sum of squares (SST): $SST = \sum (y - \bar{y})^2$</p> $SST = SSR + SSE$ <p>sum of squares regression (SSR): $SSR = \sum (\hat{y} - \bar{y})^2$</p> | <p>Chapter 14 continued:</p> $R^2 = \frac{SSR}{SST}$ <p>F-statistic for the coef. of determination: $F = \frac{SSR}{SSE/(n-2)}$</p> <p>Standard Error of the Estimate, $s_e = \sqrt{SSE/(n-2)}$. Confidence Interval (CI) for an average value of Y:</p> $CI = \hat{y}^* \pm t_{\alpha/2} s_e \sqrt{\frac{1}{n} + \frac{(x - \bar{x})^2}{\sum x^2 - ((\sum x)^2/n)}}$ <p>Prediction Interval (PI) for a specific value of y:</p> $PI = \hat{y}^* \pm t_{\alpha/2} s_e \sqrt{\frac{1}{n} + \frac{(x - \bar{x})^2}{\sum x^2 - ((\sum x)^2/n)}}$ <p>t-test statistic for the regression slope: $t = \frac{b_1 - \beta_1}{s_b}$</p> <p>the standard error of a slope: $s_b = \frac{s_e}{\sqrt{\sum x^2 - n(\bar{x})^2}}$</p> <p>confid. interval for the pop. slope: $CI = b_1 \pm t_{\alpha/2} s_b$</p> <p>Chapter 15:</p> <p>mean square regression (MSR): $MSR = SSR/k$</p> <p>mean square error (MSE): $MSE = SSE/(n - k - 1)$</p> <p>F-test stat. for the overall regression model: $F = \frac{MSR}{MSE}$</p> <p>adjusted multiple coef. of det.: $R_A^2 = 1 - (1 - R^2) \frac{n - 1}{n - k - 1}$</p> <p>variance inflation factor: $VIF_j = \frac{1}{1 - R_j^2}$</p> <p>Other Math Rule Reminders:</p> <p>$e^x = \exp(x)$ and $\ln 1 = 0$ and $\ln e = 1$</p> <p>$x! = (x)(x-1)(x-2) \cdots (2)(1)$ and $0! = 1$ and $x^0 = 1$</p> |
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Key

1. c
2. a.
3. d
4. a
5. a
6. d
7. d
8. b or d
9. a
10. e
11. d
12. c
13. e
14. d
15. b
16. a
17. e
18. b, note that the groupwise variances imply $SSW = 0 + 0 + 9 * .5 + 9 * .1 = 5.4$ we know this because $s_j^2 = SSE_j / (n_j - 1)$ and all groups have 10 observations. Then we also know that $SST = 39 * 100$ since there are 40 observations and the overall variance is 100 and the sample variance is just $SST / (n_T - 1)$. So this will give us a MSW of $5.4 / 36$ and MSB of $(3900 - 5.4) / 3 = 1298.2$ so that your F statistic is over 7000.
19. b
20. c, use $\bar{x} \pm t_{\{.025, n-1\}}(s / \sqrt{n})$
21. a

22. b

23. b, note that failing to reject (aka accepting) the null hypothesis does not mean that the null is true, it is possible that we commit a Type II error when we fail to reject the null.

24. a

25. b