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P value f table

Regression requires two types of tests: f and t tests. To find the p values for the f test you need to consult the f table. Use the degrees of freedom given in the ANOVA table (provided as part of the SPSS regression output). To find the p values for the t test you need to use the Df2 i.e. df denominator. Df denominator is specified in the ANOVA table output as mentioned above. Note: SPSS reports one tail F test values (f test is always an upper tail test!), and it reports two tail p values for T tests. In case of simple linear regression – you will always find that both one tail F test p value and two tail T test p value are the same! Alternatively, you can compute the degrees of freedom as mentioned here: Df numerator = number of x variables in the model Df denominator = sample size – number of x variables – 1 Df total = sample size – 1 Note df1 is also called df numerator, and df2 is also called df denominator Here are some facts about the F distribution. The curve is not symmetrical but skewed to the right. There is a different curve for each set of dfs. The F statistic is greater than or equal to zero. As the degrees of freedom for the numerator and for the denominator get larger, the curve approximates the normal. Other uses for the F distribution include comparing two variances and two-way Analysis of Variance. Two-Way Analysis is beyond the scope of this chapter. Try It MRSA, or Staphylococcus aureus, can cause a serious bacterial infections in hospital patients. This table shows various colony counts from different patients who may or may not have MRSA. Conc = 0.6 Conc = 0.8 Conc = 1.0 Conc = 1.2 Conc = 1.4 9 16 22 30 27 66 93 147 199 168 98 82 120 148 132 Plot of the data for the different concentrations: Test whether the mean number of colonies are the same or are different. Construct the ANOVA table (by hand or by using a TI-83, 83+, or 84+ calculator), find the p-value, and state your conclusion. Use a 5% significance level. While there are differences in the spreads between the groups, the differences do not appear to be big enough to cause concern. We test for the equality of mean number of colonies: H0 : μ1 = μ2 = μ3 = μ4 = μ5Ha: μi ≠ μj some i ≠ j The one-way ANOVA table results are shown in below. Source of Variation Sum of Squares (SS) Degrees of Freedom (df) Mean Square (MS) F Factor (Between) 10,233 5 – 1 = 4 [latex]\displaystyle\frac{{{10},{233}}}{{4}}={2},{558.25}[/latex] [latex]\displaystyle\frac{{{2},{558.25}}}{{{4},{194.9}}}={0.6099}[/latex] Error (Within) 41,949 15 – 5 = 10 Total 52,182 15 – 1 = 14 [latex]\displaystyle\frac{{{41},{949}}}{{10}}={4},{194.9}[/latex] Distribution for the test: F4,10Probability Statement: p-value = P(F > 0.6099) = 0.6649. Compare α and the p-value: α = 0.05, p-value = 0.669, α > p-value Make a decision: Since α > p-value, we do not reject H0. Conclusion: At the 5% significance level, there is insufficient evidence from these data that different levels of tryptone will cause a significant difference in the mean number of bacterial colonies formed. Example 1 Four sororities took a random sample of sisters regarding their grade means for the past term. The results are shown in the table. Mean Grades for Four Sororities Sorority 1 Sorority 2 Sorority 3 Sorority 4 2.17 2.63 2.63 3.79 1.85 1.77 3.78 3.45 2.83 3.25 4.00 3.08 1.69 1.86 2.55 2.26 3.33 2.21 2.45 3.18 Using a significance level of 1%, is there a difference in mean grades among the sororities? Solution Let μ1, μ2, μ3, μ4 be the population means of the sororities. Remember that the null hypothesis claims that the sorority groups are from the same normal distribution. The alternate hypothesis says that at least two of the sorority groups come from populations with different normal distributions. Notice that the four sample sizes are each five. Note This is an example of a balanced design, because each factor (i.e., sorority) has the same number of observations. H0: μ1 = μ2 = μ3 = μ4 Ha: Not all of the means μ1, μ2, μ3, μ4 are equal. Distribution for the test: F3,16 where k = 4 groups and n = 20 samples in total df(num)= k – 1 = 4 – 1 = 3 df(denom) = n – k = 20 – 4 = 16 Calculate the test statistic: F = 2.23 Graph: Probability statement: p-value = P(F > 2.23) = 0.1241 Compare α and the p-value: α = 0.01 p-value = 0.1241 α < p-value Make a decision: Since α < p-value, you cannot reject H0. Conclusion: There is not sufficient evidence to conclude that there is a difference among the mean grades for the sororities. Using a Calculator Put the data into lists L1, L2, L3, and L4. Press STAT and arrow over to TESTS. Arrow down to F:ANOVA. Press ENTERand Enter (L1,L2,L3,L4). The calculator displays the F statistic, the p-value and the values for the one-way ANOVA table: F = 2.2303 p = 0.1241 (p-value) Factor df = 3 SS = 2.88732 MS = 0.96244 Error df = 16 SS = 6.9044 MS = 0.431525 Try It Four sports teams took a random sample of players regarding their GPAs for the last year. The results are shown below: GPAs for Four Sports Teams Basketball Baseball Hockey Lacrosse 3.6 2.1 4.0 2.0 2.9 2.6 2.0 3.6 2.5 3.9 2.6 3.9 3.3 3.1 3.2 2.7 3.8 3.4 3.2 2.5 Use a significance level of 5%, and determine if there is a difference in GPA among the teams. With a p-value of 0.9271, we decline to reject the null hypothesis. There is not sufficient evidence to conclude that there is a difference among the GPAs for the sports teams. Example 2 A fourth grade class is studying the environment. One of the assignments is to grow bean plants in different soils. Tommy chose to grow his bean plants in soil found outside his classroom mixed with dryer lint. Tara chose to grow her bean plants in potting soil bought at the local nursery. Nick chose to grow his bean plants in soil from his mother's garden. No chemicals were used on the plants, only water. They were grown inside the classroom next to a large window. Each child grew five plants. At the end of the growing period, each plant was measured, producing the data (in inches) in this table. Tommy's Plants Tara's Plants Nick's Plants 24 25 23 21 31 27 23 23 22 30 20 30 23 28 20 Does it appear that the three media in which the bean plants were grown produce the same mean height? Test at a 3% level of significance. Solution This time, we will perform the calculations that lead to the F'statistic. Notice that each group has the same number of plants, so we will use the formula [latex]\displaystyle{F}'=\frac{{{n}\cdot{{s}_{\overline{{x}}}^{{ {2}}}}}}{{{{s}_{{\text{pooled}}}^{{2}}}}}[/latex]. First, calculate the sample mean and sample variance of each group. Tommy's Plants Tara's Plants Nick's Plants Sample Mean 24.2 25.4 24.4 Sample Variance 11.7 18.3 16.3 Next, calculate the variance of the three group means (Calculate the variance of 24.2, 25.4, and 24.4). Variance of the group means = 0.413 = [latex]\displaystyle{{s}_{\overline{{x}}}^{{ {2}}}}[/latex] Then [latex]\displaystyle{M}{S}_{{\text{between}}}={n}{{s}_{\overline{{x}}}^{{ {2}}}}={({5})}{({0.413})} text{ where } {n}={5}[/latex] is the sample size (number of plants each child grew). Calculate the mean of the three sample variances (Calculate the mean of 11.7, 18.3, and 16.3). Mean of the sample variances = 15.433 = [latex]\displaystyle{{s}_{{\text{pooled}}}^{{2}}}[/latex] Then [latex]\displaystyle{M}{S}_{{\text{within}}}={{s}_{{\text{pooled}}}^{{2}}}={15.433}[/latex]. The F statistic (or F ratio) is [latex]\displaystyle{F}=\frac{{{M}{S}_{{\text{between}}}}}{{{M}{S}_{{\text{within}}}}}=\frac{{{n}{{s}_{\overline{{x}}}^{{ {2}}}}}}{{{{s}_{{\text{pooled}}}^{{2}}}}}=\frac{{{({5})}{({0.413})}}}{{{15.433}}}={0.134}[/latex] The dfs for the numerator = the number of groups – 1 = 3 – 1 = 2. The dfs for the denominator = the total number of samples – the number of groups = 15 – 3 = 12 The distribution for the test is F2,12 and the F statistic is F = 0.134 The p-value is P(F > 0.134) = 0.8759. Decision: Since α = 0.03 and the p-value = 0.8759, do not reject H0. (Why?) Conclusion: With a 3% level of significance, from the sample data, the evidence is not sufficient to conclude that the mean heights of the bean plants are different. Using a Calculator To calculate the p-value: Press 2nd DISTR Arrow down to Fcdf(and pressENTER. Enter 0.134, E99, 2, 12) Press ENTER The p-value is 0.8759. Try It Another fourth grader also grew bean plants, but this time in a jelly-like mass. The heights were (in inches) 24, 28, 25, 30, and 32. Do a one-way ANOVA test on the four groups. Are the heights of the bean plants different? Use the same method as shown in Example 2. F = 0.9496 p-value = 0.4402 From the sample data, the evidence is not sufficient to conclude that the mean heights of the bean plants are different. References Data from a fourth grade classroom in 1994 in a private K – 12 school in San Jose, CA. Hand, D.J., F. Daly, A.D. Lunn, K.J. McConway, and E. Ostrowski. A Handbook of Small Datasets: Data for Fruitfly Fecundity. London: Chapman & Hall, 1994. Hand, D.J., F. Daly, A.D. Lunn, K.J. McConway, and E. Ostrowski. A Handbook of Small Datasets. London: Chapman & Hall, 1994, pg. 50. Hand, D.J., F. Daly, A.D. Lunn, K.J. McConway, and E. Ostrowski. A Handbook of Small Datasets. London: Chapman & Hall, 1994, pg. 118. "MLB Standings – 2012." Available online at . Mackowiak, P. A., Wasserman, S. S., and Levine, M. M. (1992), "A Critical Appraisal of 98.6 Degrees F, the Upper Limit of the Normal Body Temperature, and Other Legacies of Carl Reinhold August Wunderlich," Journal of the American Medical Association, 268, 1578-1580. Concept Review The graph of the F distribution is always positive and skewed right, though the shape can be mounded or exponential depending on the combination of numerator and denominator degrees of freedom. The F statistic is the ratio of a measure of the variation in the group means to a similar measure of the variation within the groups. If the null hypothesis is correct, then the numerator should be small compared to the denominator. A small F statistic will result, and the area under the F curve to the right will be large, representing a large p-value. When the null hypothesis of equal group means is incorrect, then the numerator should be large compared to the denominator, giving a large F statistic and a small area (small p-value) to the right of the statistic under the F curve. When the data have unequal group sizes (unbalanced data), then techniques need to be used for hand calculations. In the case of balanced data (the groups are the same size) however, simplified calculations based on group means and variances may be used. In practice, of course, software is usually employed in the analysis. As in any analysis, graphs of various sorts should be used in conjunction with numerical techniques. Always look of your data! OpenStax, Statistics, "Facts About the F Distribution," licensed under a CC BY 3.0 license. The distribution used for the hypothesis test is a new one. It is called the F distribution, invented by George Snedecor but named in honor of Sir Ronald Fisher, an English statistician. The F statistic is a ratio (a fraction). There are two sets of degrees of freedom; one for the numerator and one for the denominator. For example, if F follows an F distribution and the number of degrees of freedom for the numerator is four, and the number of degrees of freedom for the denominator is ten, then F ~ F4,10. To calculate the F ratio, two estimates of the variance are made. Variance between samples: An estimate of σ2 that is the variance of the sample means multiplied by n (when the sample sizes are the same.). If the samples are different sizes, the variance between samples is weighted to account for the different sample sizes. The variance is also called variation due to treatment or explained variation. Variance within samples: An estimate of σ2 that is the average of the sample variances (also known as a pooled variance). When the sample sizes are different, the variance within samples is weighted. The variance is also called the variation due to error or unexplained variation. SSbetween = the sum of squares that represents the variation among the different samples SSwithin = the sum of squares that represents the variation within samples that is due to chance. To find a "sum of squares" means to add together squared quantities that, in some cases, may be weighted. We used sum of squares to calculate the sample variance and the sample standard deviation in (Figure). MS means "mean square." MSbetween is the variance between groups, and MSwithin is the variance within groups. Calculation of Sum of Squares and Mean Square k = the number of different groups nj = the size of the jth group sj = the sum of the values in the jth group n = total number of all the values combined (total sample size: ∑nj) x = one value: ∑x = ∑sj Sum of squares of all values from every group combined: ∑x2 Between group variability: SStotal = ∑x2 – Total sum of squares: ∑x2 – Explained variation: sum of squares representing variation among the different samples: SSbetween = Unexplained variation: sum of squares representing variation within samples due to chance: df's for different groups (df's for the numerator): df = k – 1 Equation for errors within samples (df's for the denominator): dfwithin = n – k Mean square (variance estimate) explained by the different groups: MSbetween = Mean square (variance estimate) that is due to chance (unexplained): MSwithin = MSbetween and MSwithin can be written as follows: The one-way ANOVA test depends on the fact that MSbetween can be influenced by population differences among means of the several groups. Since MSwithin compares values of each group to its own group mean, the fact that group means might be different does not affect MSwithin. The null hypothesis says that all groups are samples from populations having the same normal distribution. The alternate hypothesis says that at least two of the sample groups come from populations with different normal distributions. If the null hypothesis is true, MSbetween and MSwithin should both estimate the same value. Note The null hypothesis says that all the group population means are equal. The hypothesis of equal means implies that the populations have the same normal distribution, because it is assumed that the populations are normal and that they have equal variances. F-Ratio or F Statistic If MSbetween and MSwithin estimate the same value (following the belief that H0 is true), then the F-ratio should be approximately equal to one. Mostly, just sampling errors would contribute to variations away from one. As it turns out, MSbetween consists of the population variance plus a variance produced from the differences between the samples. MSwithin is an estimate of the population variance. Since variances are always positive, if the null hypothesis is false, MSbetween will generally be larger than MSwithin.Then the F-ratio will be larger than one. However, if the population effect is small, it is not unlikely that MSwithin will be larger in a given sample. The foregoing calculations were done with groups of different sizes. If the groups are the same size, the calculations simplify somewhat and the F-ratio can be written as: F-Ratio Formula when the groups are the same size where ... n = the sample size dfnumerator = k – 1 dfdenominator = n – k s2 pooled = the mean of the sample variances (pooled variance) = the variance of the sample means Data are typically put into a table for easy viewing. One-Way ANOVA results are often displayed in this manner by computer software. Source of variation Sum of squares (SS) Degrees of freedom (df) Mean square (MS) F Factor (Between) SS(Factor) k – 1 MS(Factor) = SS(Factor)/(k – 1) F = MS(Factor)/MS(Error) Error (Within) SS(Error) n – k MS(Error) = SS(Error)/(n – k) Total SS(Total) n – 1 Three different diet plans are to be tested for mean weight loss. The entries in the table are the weight losses for the different plans. The one-way ANOVA results are shown in (Figure). Plan 1: n1 = 4 Plan 2: n2 = 3 Plan 3: n3 = 3 5 3.5 8 4.5 7 4 4 3.5 3 4.5 s1 = 16.5, s2 =15, s3 = 15.5 Following are the calculations needed to fill in the one-way ANOVA table. The table is used to conduct a hypothesis test. where n1 = 4, n2 = 3, n3 = 3 and n = n1 + n2 + n3 = 10 Source of variation Sum of squares (SS) Degrees of freedom (df) Mean square (MS) F Factor (Between) SS(Factor) = SS(Between) = 2.2458 k – 1 = 3 groups – 1 = 2 MS(Factor) = SS(Factor)/(k – 1) = 2.2458/2 = 1.1229 F = MS(Factor)/MS(Error) = 1.1229/2.9792 = 0.3769 Error (Within) SS(Error) = SS(Within) = 20.8542 n – k = 10 total data – 3 groups = 7 MS(Error) = SS(Error)/(n – k) = 20.8542/7 = 2.9792 Total SS(Total) = 2.2458 + 20.8542 = 23.1 n – 1 = 10 total data – 1 = 9 Try It As part of an experiment to see how different types of soil cover would affect slicing tomato production, Marist College students grew tomato plants under different soil cover conditions. Groups of three plants each had one of the following treatments bare soil a commercial ground cover black plastic straw compost All plants grew under the same conditions and were the same variety. Students recorded the weight (in grams) of tomatoes produced by each of the n = 15 plants: Bare: n1 = 3 Ground Cover: n2 = 3 Plastic: n3 = 3 Straw: n4 = 3 Compost: n5 = 3 2,625 5,348 6,583 7,285 6,277 2,997 5,682 8,560 6,897 7,818 4,915 5,482 3,830 9,230 8,677 Create the one-way ANOVA table. Enter the data into lists L1, L2, L3, L4 and L5. Press STAT and arrow over to TESTS. Arrow down to ANOVA. Press ENTER and enter L1, L2, L3, L4, L5). Press ENTER. The table was filled in with the results from the calculator. One-Way ANOVA table: Source of variation Sum of squares (SS) Degrees of freedom (df) Mean square (MS) F Factor (Between) 36,648,561 5 – 1 = 4 Error (Within) 20,446,726 15 – 5 = 10 Total 57,095,287 15 – 1 = 14 The one-way ANOVA hypothesis test is always right-tailed because larger F-values are way out in the right tail of the F-distribution curve and tend to make us reject H0. Let's return to the slicing tomato exercise in (Figure). The means of the tomato yields under the five mulching conditions are represented by μ1, μ2, μ3, μ4, μ5. We will conduct a hypothesis test to determine if all means are the same or at least one is different. Using a significance level of 5%, test the null hypothesis that there is no difference in mean yields among the five groups against the alternative hypothesis that at least one mean is different from the rest. The null and alternative hypotheses are: H0: μ1 = μ2 = μ3 = μ4 = μ5 Ha: μi ≠ μj some i ≠ j The one-way ANOVA results are shown in (Figure) Source of variation Sum of squares (SS) Degrees of freedom (df) Mean square (MS) F Factor (Between) 36,648,561 5 – 1 = 4 Error (Within) 20,446,726 15 – 5 = 10 Total 57,095,287 15 – 1 = 14 Distribution for the test: F4,10 df(num) = 5 – 1 = 4 df(denom) = 15 – 5 = 10 Test statistic:F = 4.4810 Probability Statement:p-value = P(F > 4.481) = 0.0248. Compare α and the p-value:α = 0.05, p-value = 0.0248 Make a decision: Since α > p-value, we cannot accept H0. Conclusion: At the 5% significance level, we have reasonably strong evidence that differences in mean yields for slicing tomato plants grown under different mulching conditions are unlikely to be due to chance alone. We may conclude that at least some of mulches led to different mean yields. Try It MRSA, or Staphylococcus aureus, can cause a serious bacterial infections in hospital patients. (Figure) shows various colony counts from different patients who may or may not have MRSA. The data from the table is plotted in (Figure). Conc = 0.6 Conc = 0.8 Conc = 1.0 Conc = 1.2 Conc = 1.4 9 16 22 30 27 66 93 147 199 168 98 82 120 148 132 Plot of the data for the different concentrations: Test whether the mean number of colonies are the same or are different. Construct the ANOVA table, find the p-value, and state your conclusion. Use a 5% significance level. While there are differences in the spreads between the groups (see (Figure)), the differences do not appear to be big enough to cause concern. We test for the equality of mean number of colonies: Ha: μi ≠ μj some i ≠ j The one-way ANOVA table results are shown in (Figure). Source of variation Sum of squares (SS) Degrees of freedom (df) Mean square (MS) F Factor (Between) 10,233 5 – 1 = 4 Error (Within) 41,949 15 – 5 = 10 Total 52,182 15 – 1 = 14 Distribution for the test:F4,10 Probability Statement:p-value = P(F > 0.6099) = 0.6649. Compare α and the p-value:α = 0.05, p-value = 0.669, α > p-value Make a decision: Since α > p-value, we do not reject H0. Conclusion: At the 5% significance level, there is insufficient evidence from these data that different levels of tryptone will cause a significant difference in the mean number of bacterial colonies formed. Four sororities took a random sample of sisters regarding their grade means for the past term. The results are shown in (Figure). Mean grades for four sororities Sorority 1 Sorority 2 Sorority 3 Sorority 4 2.17 2.63 2.63 3.79 1.85 1.77 3.78 3.45 2.83 3.25 4.00 3.08 1.69 1.86 2.55 2.26 3.33 2.21 2.45 3.18 Using a significance level of 1%, is there a difference in mean grades among the sororities? Let μ1, μ2, μ3, μ4 be the population means of the sororities. Remember that the null hypothesis claims that the sorority groups are from the same normal distribution. The alternate hypothesis says that at least two of the sorority groups come from populations with different normal distributions. Notice that the four sample sizes are each five. Note This is an example of a balanced design, because each factor (i.e., sorority) has the same number of observations. H0: Ha: Not all of the means are equal. Distribution for the test:F3,16 where k = 4 groups and n = 20 samples in total df(num)= k – 1 = 4 – 1 = 3 df(denom) = n – k = 20 – 4 = 16 Calculate the test statistic:F = 2.23 Graph: Probability statement:p-value = P(F > 2.23) = 0.1241 Compare α and the p-value:α = 0.01 p-value = 0.1241 α < p-value Make a decision: Since α < p-value, you cannot reject H0. Conclusion: There is not sufficient evidence to conclude that there is a difference among the mean grades for the sororities. Try It Four sports teams took a random sample of players regarding their GPAs for the last year. The results are shown in (Figure). GPAs for four sports teams Basketball Baseball Hockey Lacrosse 3.6 2.1 4.0 2.0 2.9 2.6 2.0 3.6 2.5 3.9 2.6 3.9 3.3 3.1 3.2 2.7 3.8 3.4 3.2 2.5 Use a significance level of 5%, and determine if there is a difference in GPA among the teams. With a p-value of 0.9271, we decline to reject the null hypothesis. There is not sufficient evidence to conclude that there is a difference among the GPAs for the sports teams. A fourth grade class is studying the environment. One of the assignments is to grow bean plants in different soils. Tommy chose to grow his bean plants in soil found outside his classroom mixed with dryer lint. Tara chose to grow her bean plants in potting soil bought at the local nursery. Nick chose to grow his bean plants in soil from his mother's garden. No chemicals were used on the plants, only water. They were grown inside the classroom next to a large window. Each child grew five plants. At the end of the growing period, each plant was measured, producing the data (in inches) in (Figure). Tommy's plants Tara's plants Nick's plants 24 25 23 21 31 27 23 23 22 30 20 30 23 28 20 Does it appear that the three media in which the bean plants were grown produce the same mean height? Test at a 3% level of significance. This time, we will perform the calculations that lead to the F′ statistic. Notice that each group has the same number of plants, so we will use the formula F′ = . First, calculate the sample mean and sample variance of each group. Tommy's plants Tara's plants Nick's plants Sample mean 24.2 25.4 24.4 Sample variance 11.7 18.3 16.3 Next, calculate the variance of the three group means (Calculate the variance of 24.2, 25.4, and 24.4). Variance of the group means = 0.413 = Then MSbetween = = (5)(0.413) where n = 5 is the sample size (number of plants each child grew). Calculate the mean of the three sample variances (Calculate the mean of 11.7, 18.3, and 16.3). Mean of the sample variances = 15.433 = s2pooled Then MSwithin = s2pooled = 15.433. The F statistic (or F ratio) is The dfs for the numerator = the number of groups – 1 = 3 – 1 = 2. The dfs for the denominator = the total number of samples – the number of groups = 15 – 3 = 12 The distribution for the test is F2,12 and the F statistic is F = 0.134 The p-value is P(F > 0.134) = 0.8759. Decision: Since α = 0.03 and the p-value = 0.8759, then you cannot reject H0. (Why?) Conclusion: With a 3% level of significance, from the sample data, the evidence is not sufficient to conclude that the mean heights of the bean plants are different. The notation for the F distribution is F ~ Fdf(num),df(denom) where df(num) = dfbetween and df(denom) = dfwithin The mean for the F distribution is dfbetween = df(num) = k – 1 dfwithin = df(denom) = n – k MSbetween = MSwithin = F = k = the number of groups nj = the size of the jth group sj = the sum of the values in the jth group n = the total number of all values (observations) combined x = one value (one observation) from the data = the variance of the sample means = the mean of the sample variances (pooled variance) Use the following information to answer the next eight exercises. Groups of men from three different areas of the country are to be tested for mean weight. The entries in (Figure) are the weights for the different groups. Group 1 Group 2 Group 3 216 202 170 198 213 165 240 284 182 187 228 197 176 210 201 What is the Sum of Squares Factor? What is the Sum of Squares Error? What is the df for the numerator? What is the df for the denominator? What is the Mean Square Factor? What is the Mean Square Error? Use the following information to answer the next eight exercises. Girls from four different soccer teams are to be tested for mean goals scored per game. The entries in (Figure) are the goals per game for the different teams. Team 1 Team 2 Team 3 Team 4 1 2 0 3 2 3 1 4 0 2 1 4 3 4 0 3 2 4 0 2 What is the df for the numerator? What is the df for the denominator? Judging by the F statistic, do you think it is likely or unlikely that you will reject the null hypothesis? Because a one-way ANOVA test is always right-tailed, a high F statistic corresponds to a low p-value, so it is likely that we cannot accept the null hypothesis. Use the following information to answer the next three exercises. Suppose a group is interested in determining whether teenagers obtain their drivers licenses at approximately the same average age across the country. Suppose that the following data are randomly collected from five teenagers in each region of the country. The numbers represent the age at which teenagers obtained their drivers licenses. Northeast South West Central East 16.3 16.9 16.4 16.2 17.1 16.1 16.5 16.5 16.6 17.2 16.4 16.4 16.6 16.5 16.6 16.5 16.2 16.1 16.4 16.8 ________ ________ ________ ________ ________ ________ ________ ________ ________ ________ H0: μ1 = μ2 = μ3 = μ4 = μ5 Hα: At least any two of the group means μ1, μ2, …, μ5 are not equal. degrees of freedom – numerator: df(num) = _________ degrees of freedom – denominator: df(denom) = ________