

ANOVA

MULTIPLE CHOICE QUESTIONS

In the following multiple-choice questions, select the best answer.

1. Analysis of variance is a statistical method of comparing the _____ of several populations.
 - a. standard deviations
 - b. variances
 - c. means
 - d. proportions
 - e. none of the above

2. The _____ sum of squares measures the variability of the observed values around their respective treatment means.
 - a. treatment
 - b. error
 - c. interaction
 - d. total

3. The _____ sum of squares measures the variability of the sample treatment means around the overall mean.
 - a. treatment
 - b. error
 - c. interaction
 - d. total

4. If the true means of the k populations are equal, then MSTR/MSE should be:
 - a. more than 1.00
 - b. close to 1.00
 - c. close to 0.00
 - d. close to -1.00
 - e. a negative value between 0 and - 1
 - f. not enough information to make a decision

5. If the MSE of an ANOVA for six treatment groups is known, you can compute
 - a. df1
 - b. the standard deviation of each treatment group
 - c. the pooled standard deviation
 - d. b and c
 - e. all answers are correct

6. To determine whether the test statistic of ANOVA is statistically significant, it can be compared to a critical value. What two pieces of information are needed to determine the critical value?
 - a. sample size, number of groups
 - b. mean, sample standard deviation
 - c. expected frequency, obtained frequency
 - d. MSTR, MSE

7. Which of the following is an assumption of one-way ANOVA comparing samples from three or more experimental treatments?
- All the response variables within the k populations follow a normal distributions.
 - The samples associated with each population are randomly selected and are independent from all other samples.
 - The response variable within each of the k populations have equal variances.
 - All of the above.
8. The error deviations within the SSE statistic measure distances:
- within groups
 - between groups
 - both (a) and (b)
 - none of the above
 - between each value and the grand mean
9. When the k population means are truly different from each other, it is likely that the average error deviation:
- is relatively large compared to the average treatment deviations
 - is relatively small compared to the average treatment deviations
 - is about equal to the average treatment deviation
 - none of the above
 - differ significantly between at least two of the populations
10. As variability due to chance decreases, the value of F will
- increase
 - stay the same
 - decrease
 - can't tell from the given information
11. In a study, subjects are randomly assigned to one of three groups: control, experimental A, or experimental B. After treatment, the mean scores for the three groups are compared. The appropriate statistical test for comparing these means is:
- the correlation coefficient
 - chi square
 - the t-test
 - the analysis of variance
12. In one-way ANOVA, which of the following is used within the F -ratio as a measurement of the variance of individual observations?
- SSTR
 - MSTR
 - SSE
 - MSE
 - none of the above

13. When conducting a one-way ANOVA, the _____ the between-treatment variability is when compared to the within-treatment variability, the _____ the value of F_{DATA} will tend to be.
- smaller, larger
 - smaller, smaller
 - larger, larger
 - smaller, more random
 - larger, more random
14. When conducting an ANOVA, F_{DATA} will always fall within what range?
- between negative infinity and infinity
 - between 0 and 1
 - between 0 and infinity
 - between 1 and infinity
15. If $F_{\text{DATA}} = 5$, the result is statistically significant
- Always
 - Sometimes
 - Never
16. If $F_{\text{DATA}} = 0.9$, the result is statistically significant
- Always
 - Sometimes
 - Never
17. You obtained a significant test statistic when comparing three treatments in a one-way ANOVA. In words, how would you interpret the alternative hypothesis H_A ?
- All three treatments have different effects on the mean response.
 - Exactly two of the three treatments have the same effect on the mean response.
 - At least two treatments are different from each other in terms of their effect on the mean response.
 - All of the above.
 - None of the above.
18. You carried out an ANOVA on a preliminary sample of data. You then collected additional data from the same groups; the difference being that the sample sizes for each group were increased by a factor of 10, and the within-group variability has decreased substantially. Which of the following statements is NOT correct.
- The degrees of freedom associated with the error term has increased
 - The degrees of freedom associated with the treatment term has increased
 - SSE has decreased
 - F_{DATA} has changed
 - F_{CRIT} has changed

19. If the sample means for each of k treatment groups were identical (yes, this is extremely unlikely), what would be the observed value of the ANOVA test statistic?
- 1.0
 - 0.0
 - A value between 0.0 and 1.0
 - A negative value
 - Infinite
20. If F_{DATA} follows an F distribution with $df_1=4$ and $df_2=5$, what is the boundary value of F where $P(F_{\text{DATA}} < F) = 0.95$?
- 0.05
 - 5.1922
 - 6.2561
 - 15.5291
 - 11.3919
21. Suppose the critical region for a certain test of the null hypothesis is of the form $F > 9.48773$ and the computed value of F from the data is 1.86. Then:
- H_0 should be rejected.
 - The significance level is given by the area to the left of 9.48773 under the appropriate F distribution.
 - The significance level is given by the area to the right of 9.48773 under the appropriate F distribution.
 - The hypothesis test is two-tailed
 - None of these.
22. Assuming that the null hypothesis being tested by ANOVA is false, the probability of obtaining a F -ratio that exceeds the value reported in the F table as the 95th percentile is:
- less than .05.
 - equal to .05.
 - greater than .05.
23. Assuming no bias, the total variation in a response variable is due to error (unexplained variation) plus differences due to treatments (known variation). If known variation is large compared to unexplained variation, which of the following conclusions is the best?
- There is no evidence for a difference in response due to treatments.
 - There is evidence for a difference in response due to treatments.
 - There is significant evidence for a difference in response due to treatments
 - The treatments are not comparable.
 - The cause of the response is due to something other than treatments.

24. What would happen if instead of using an ANOVA to compare 10 groups, you performed multiple t -tests?
- Nothing, there is no difference between using an ANOVA and using a t -test.
 - Nothing serious, except that making multiple comparisons with a t -test requires more computation than doing a single ANOVA.
 - Sir Ronald Fischer would be turning over in his grave; he put all that work into developing ANOVA, and you use multiple t -tests
 - Making multiple comparisons with a t -test increases the probability of making a Type I error.
25. What is the function of a post-test in ANOVA?
- Determine if any statistically significant group differences have occurred.
 - Describe those groups that have reliable differences between group means.
 - Set the critical value for the F test (or chi-square).
26. An investigator randomly assigns 30 college students into three equal size study groups (early-morning, afternoon, late-night) to determine if the period of the day at which people study has an effect on their retention. The students live in a controlled environment for one week, on the third day of the experimental treatment is administered (study of predetermined material). On the seventh day the investigator tests for retention. In computing his ANOVA table, he sees that his MS within groups is larger than his MS between groups. What does this result indicate?
- An error in the calculations was made.
 - There was more than the expected amount of variability between groups.
 - There was more variability between subjects within the same group than there was between groups.
 - There should have been additional controls in the experiment.
27. In ANOVA with 4 groups and a total sample size of 44, the computed F statistic is 2.33 In this case, the p -value is:
- exactly 0.05
 - less than 0.05
 - greater than 0.05
 - cannot tell - it depends on what the SSE is
28. Assume that there is no overlap between the box and whisker plots for three drug treatments where each drug was administered to 35 individuals. The box plots for these data:
- provide no evidence for, or against, the null hypothesis of ANOVA
 - represent evidence for the null hypothesis of ANOVA
 - represent evidence against the null hypothesis of ANOVA
 - can be very misleading, you should not be looking at box plots in this setting
29. ANOVA was used to test the outcomes of three drug treatments. Each drug was given to 20 individuals. The MSE for this analysis was 16. What is the standard deviation for all 60 individuals sampled for this study?
- 6.928
 - 48
 - 16
 - 4

30. A fisheries researcher wishes to test for a difference in mean weights of a single species of fish caught by fishermen in three different lakes in Nova Scotia. The significance level for the test will be 0.05. Complete the following partial ANOVA table and use it to answer questions 31.1 to 31.4

Source	d.f.	SS	MS	F
Treatment		17.04		
Error	9			
Total		31.23		

- 30.1 The null hypothesis for this analysis is:
- Not all the fish populations have the same mean.
 - At least one of the fish populations has a different mean.
 - $\mu_1 = \mu_2 = \mu_3$
 - $\mu_1 = \mu_2 = \mu_3 = 0$
 - None of these.
- 30.2 The value of F_{DATA} for this test is:
- 8.52
 - 5.39
 - 2.00
 - 0.1854
- 30.3 The value of F_{CRIT} for this test is:
- 3.5874
 - 3.8625
 - 3.9824
 - 4.2565
- 30.4 If you pooled all the individuals from all three lakes into a single group, they would have a standard deviation of:
- 1.257
 - 1.580
 - 3.767
 - 14.19
- 30.5 What is the appropriate interpretation of this test?
- Reject H_0 : All three fish populations have different mean weights.
 - Reject H_0 : Exactly two of the three fish populations have the same means.
 - Reject H_0 : At least one of the fish populations differs from the others in terms of their mean weight.
 - Fail to reject H_0 : The mean weights of the fish in these three populations are the same
 - Fail to reject H_0 : There is insufficient evidence for differences in mean weights of the fish from these three populations.

MULTIPLE CHOICE ANSWERS

1. c	11. d	21. c	30.1 c
2. b	12. c	22. a	30.2 b
3. a	13. b	23. b	30.3 d
4. b	14. c	24. d	30.4 a
5. c	15. b	25. b	30.5 c
6. a	16. c	26. c	
7. d	17. c	27. c	
8. a	18. b	28. c	
9. b	19. b	29. d	
10. a	20. b		

COMPLETE ANOVA TABLE REQUIRED FOR QUESTION 31

Source	d.f.	SS	MS	F
Treatment	2	17.04	8.52	5.392
Error	9	14.19	1.58	
Total	11	31.23		