Multiple Choice Questions
Analysis of Variance - Single factor completely randomized design

The following questions refer to the following situation

Health and Welfare wishes to investigate if the tar contents (milligrams) varies among four brand of cigarettes. Three packs of each brand were selected, and one cigarette from each pack was placed in a smoking machine to determine the tar content. An Analysis of Variance was performed and here are the results (some parts are hidden):

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F
MODEL	3	***.********	116.00000000	*****	0.0028
ERROR	**	80.00000000	**********		
CORR. TOTAL	**	428.00000000			

SOURCE	DF	TYPE III SS	F VALUE	PR > F
BRAND	3	348.00000000	*****	0.0028

1. The value of the F-statistic for testing the equality of the means is:

   (a) 4.35
   (b) .0028
   (c) 13.05
   (d) 11.60
   (e) 116.00

   Solution: d
   Past performance 1990 Apr - 75%
   Past performance 1991 Feb - 63% (c-27%)
   Past performance 1993 Feb - 84% (c-10%)

2. The hypothesis would be rejected at α=0.05 if the test statistic is greater than:

   (a) 4.07
   (b) 3.86
   (c) 8.85
   (d) 8.81
   (e) 3.59

   Solution: a
   Past performance 1990 Apr - 79%
   Past performance 1991 Feb - 61% (b-31%)
   Past performance 1993 Feb - 86% (b-12%)

3. Which of the following is correct:

   (a) Because the p-value is small, there is evidence that all the brands differ from each other in the mean amount of tar present.
   (b) Because the p-value is small, there is no evidence that any of the brands differ in the mean tar content.
   (c) Because the p-value is small, there is evidence that at least one brand has a different mean tar content from the other brands.
   (d) Because the p-value is small, there is no evidence that at least one brand has a different mean tar content from the other brands.
   (e) Because the p-value is small, there is evidence that all of brands have the same mean tar content.

   Solution: c
   Past performance 1993 Feb - 95%

   Since the p-value is 0.0028 the hypothesis of equal means is rejected. Consequently a multiple comparison procedure was performed. Here is a portion of the output:

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T TESTS (LSD) FOR VARIABLE: TAR
NOTE: THIS TEST CONTROLS THE TYPE I COMPARISONWISE ERROR RATE,
  NOT THE EXPERIMENTWISE ERROR RATE
      ALPHA=0.05  DF=*  MSE=***
      CRITICAL VALUE OF T=2.30600
      LEAST SIGNIFICANT DIFFERENCE=5.9541

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.
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T	GROUPING	MEAN	N	BRAND
	A	122.000	3	Wheezer
	B	112.000	3	Choker
	B			
	B	110.000	3	Hacker
	B			
	B	108.000	3	Killer

4. Which statement is not correct ?

   (a) The comparison-wise error rate is the probability of a Type I error in any comparison.

   (b) The experiment-wise error rate is the probability of at least one Type I error in all possible comparisons

   (c) There is no evidence of a difference between the average tar content of the Hacker and Killer brands.

   (d) The Hacker brand appears to have lower mean tar content than the Choker brand.

   (e) Two sample means must differ by the Least Significant Difference (5.9541) before the corresponding population means are declared different.

   Solution: d
   Past performance 1990 Apr - 62% (B-15%)

5. The analyst now wishes to perform a new experiment to distinguish among three different brands. She believes that the value of 4 is a good estimate of the population standard deviation. What is the estimated sample size to be 80% sure of detecting a 5 mg. difference in the mean tar content when testing at α=0.05?

   (a) 12 of each brand for a total of 36 cigarettes

   (b) 12 cigarettes in total; four of each brand

   (c) 14 of each brand for a total of 42 cigarettes

   (d) 14 cigarettes in total; five cigarettes in two brands, four in the third

   (e) 15 cigarettes in total; five of each of three brands.

   Solution: c
   Past performance 1990 Apr - 76% (E-13%)
   Past performance 1991 Feb - 86%

6. Suppose the analyst wishes to repeat the experiment blocking by the type of inhalation of smokers. Which of the following is NOT CORRECT about a randomized complete block design?

   (a) Every block is randomized separately from every other block.

   (b) Every treatment must appear at least once in every block.

   (c) Blocking is used to remove the effects of another factor (not of interest) from the comparison of the levels of the primary factor.

   (d) The ANOVA table will have another line in it for the contribution to the variability from the blocks.

   (e) Block should contain experimental units that are as different as possible from each other.

   Solution: e
   Past performance 1990 Apr - 79%

The following questions refer to the following situation.

Some varieties of nematodes (round worms that live in soil and are frequently so small that they are invisible to the naked eye) feed on the roots of lawn grasses and crops such as strawberries and tomatoes. The pest, which is particularly troublesome in warm climates, can be treated by the application of nematocides. However, because of the size of the worms, it is very difficult to count them directly. Hence, the yield of a crop is used as a surrogate for the the number of worms. Four brands of nematocides are to be compared. Twelve plots of land of comparable fertility that were suffering from nematodes were planted with a crop. Each nematocide was applied to three plots; the assignment of the nematocide to the plot was made at random. At harvest time, the yields of each plot were recorded and part of the ANOVA table appears below:

Source	df	SS	MS	F-value
Nematocides	*	3.456	*	*
Error	8	1.200	*	
Total	11	4.656		

7. The value of the test statistics to test the hypothesis of no differences in the mean yields among the four brands is:

   (a) 23.04

   (b) 2.89

   (c) 3.46

   (d) 1.20

   (e) 7.68

Solution: e
Past performance 1990 Feb - 90%

8. The rejection criterion is (at α= 0.05):

   (a) Reject H if $F* > 7.59$
   (b) Reject H if $F* > 3.59$
   (c) Reject H if $F* > 4.07$
   (d) Reject H if $F* > 2.60$
   (e) Reject H if $F* > 8.85$

   Solution: c
   Past performance 1990 Feb - 92%

9. Suppose that based upon this experiment, the scientist wishes to be 80% sure of detecting a difference of about 0.45 kg/plot in the average yield among the four nematocides when testing at α=0.05. She decides to use 0.15 as an estimate of the population variance. Then:

   (a) The required sample size is about 20 plots per nematocide for a total of 80 plots.
   (b) The required total sample size is 20 plots, i.e., 5 plots per nematocide.
   (c) The required sample size is about 4 plots per nematocide for a total of 16 plots.
   (d) The required total sample size is 4 plots, i.e., 1 plot per nematocide.
   (e) The required sample size cannot be determined because the individual population means are not known.

   Solution: a
   Past performance 1990 Feb - 40% (A-40%, C-46%)

10. What is the best reason for randomly assigning treatment levels to the experimental units?

    (a) Randomization make the experiment easier to conduct because we can apply the nematocides in any pattern rather than in a systematic fashion.
    (b) Randomization will tend to average out all other uncontrolled factors such as soil fertility so that they are not confounded with the treatment effects.
    (c) Randomization makes the analysis easier because the data can be collected and entered into the computer in any order.

(d) Randomization is required by statistical consultants before they will help you analyze the experiment.

(e) Randomization implies that it is not necessary to be careful during the experiment, during data collection, and during data analysis.

Solution: b
Past performance 1990 Feb - 97%

11. A possible Type I error in this experiment would be to:

(a) Conclude that the mean yields of the four nematocides are equal when in fact at least one is not equal.

(b) Conclude that the mean yields of the four nematocides are equal when in fact they are equal.

(c) Conclude that the mean yields of the four nematocides are unequal when in fact at least one is not equal.

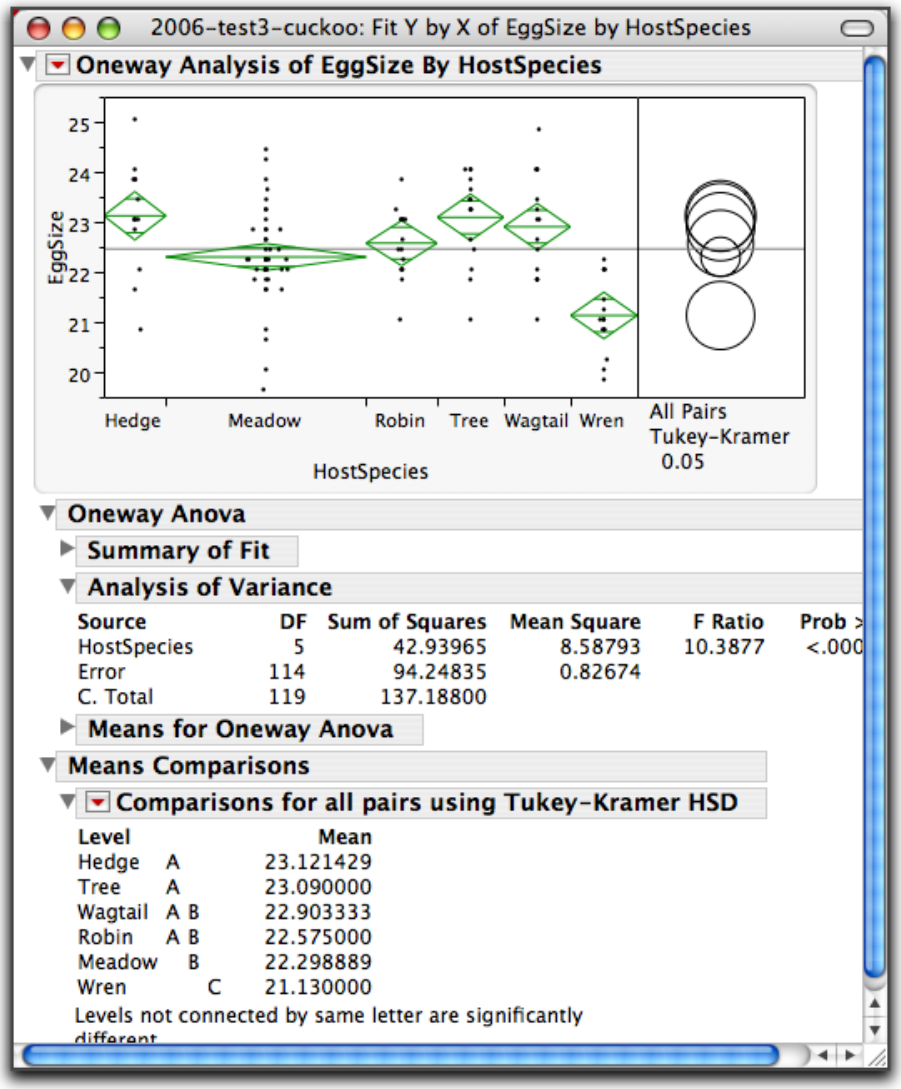
(d) Conclude that the mean yields of the four nematocides are unequal when in fact they are equal.

(e) Fail this exam because you used the osmosis method of studying.

Solution: d
Past performance 1990 Feb - 82%

The next 3 questions refer to the following situation.

Cuckoo birds lay their eggs in the nests of other species (the host species). Can cuckoo birds modify their eggs sizes according to the nest of the host species. A sample of nests containing a cuckoo egg were found and the size of the cuckoo egg in the host species nest was measured. The following output was obtained:



12. Which is the null and alternate hypothesis?

    (a) H: all sample means are equal;
    A: at least one sample mean differs from the others.

    (b) H: all host species have the same population mean cuckoo egg size;

    A: at least one population mean differs from the others.

    (c) H: all eggs are the same size:
    A: at least one egg differs in size from the others.

(d) H: all host species are the same;
A: at least one host species is different from the others.

(e) H: all host species have the same size eggs;
A: at least one host species has different sized eggs from the others.

Solution: b
Past performance 2006 Dec - 38% (30%-a; 19%-c)

13. Which is **CORRECT** about this experiment.

(a) This is a paired experiment because all host species were measured more than once.

(b) This experiment is unbalanced with unequal number of eggs measured from each host species.

(c) There is no need to carefully select a random sample of host species nests because the sample size is large.

(d) The ANOVA methods tests if the variances are equal across all treatment groups.

(e) In the Analysis of Variance (ANOVA) method, the F-test can be thought of as test of equal variances.

Solution: b - rats a typing error made the original have no answer

14. Which of the following is **CORRECT**?

(a) Because the p-value is small, there is very strong evidence that the means are equal.

(b) The F-ratio of 10.4 tests if all the individual values are the same.

(c) Because some confidence diamonds do not overlap, there is evidence that not all means are equal.

(d) The Tukey-Kramer output shows that all the means are different from each other.

(e) The comparison circles show that the eggs from Wren nests are all a different size than eggs from other host species.

Solution: c
Past performance 2006 Dec - 71% (20%-e)