### Dire Dawa University

# College of Natural and Computational Sciences

Department of Statistics

## Design and Analysis of Experiments (Stat3042) Test for 3rd year Statistics Students

Time Allowed: 1:30 hrs Max score: 30%

Date: Nov 6, 2024

Use:  $F_{0.05,2,12} = 3.895$ ,  $F_{0.025,2,12} = 5.096$ 

*Name:* \_\_\_\_\_\_

ID <u>No.</u>\_\_\_\_\_\_Section: \_\_\_\_\_\_

### Part I: True or False [1.5 pt each]

- 1. Engineers and scientists use Design of experiments for system improvement and decision-making. <u>True</u>
- 2. Mechanistic models derived from experimental data when the system is not fully understood. <u>False</u>
- 3. The P-value is the probability that the test statistic will take a value at least as extreme as the observed value, assuming the null hypothesis  $H_0$  is true. True
- 4. SSE measures differences due to random error within treatments True
- 5. Analysis of Variance (ANOVA) partitions total variability into component parts <u>True</u>

### Part II: Choose the best answer. [1.5 pt each]

- 1. Which one the following strategy of experiment Test each factor individually, holding others constant.
  - A) Best-Guess Approach B) One-Factor-at-a-Time Approach C) Factorial Experiments
- 2. Which one of the following the t-test assumptions
  - A) The samples drawn from independent populations.
  - B) The populations can be described by a normal distribution.
  - C) The variances of both populations are equal.
  - D) All

- 3. Which one of the following is the impact of larger Sample Size
  - A) Narrower confidence intervals
  - B) More precise estimates
  - C) Increased statistical power
  - D) All
- 4. Which one of the following is the formal test to check the assumptions two Sample t-test
  - A) Normality of the data using the Shapiro-Wilk test.
  - B) Visual inspection with Q-Q plots.
  - C) Equality of variances using Levene's and Bartlett's tests.
  - D) A and C
- 5. Which one of the following Mean Model ANOVA

A) 
$$y_{ij} = \mu_i + \epsilon_{ij}$$
 B)  $y_{ij} = \mu_i + \tau_i + \epsilon_{ij}$  C)  $\mu_i + \tau_i + \beta_j + \epsilon_{ij}$  D) None

### Part III: Short Answer [1 pt each]

- 1. The general approach to planning and conducting the experiment is called <u>the strategy of</u> <u>experimentation</u>
- 2. The assumptions of equal variance and normality can be checked using <u>a normal</u> <u>probability plot</u>
- 3. *SSTreatments* Measures differences between treatment means

Part II: Workout Show all Necessary Steps

- 1. List the Strategy of Experimentation [3 pt]
  - ✓ Best-Guess Approach
  - ✓ OFAT
  - ✓ Factorial Experiments

2. A rental car company wants to investigate whether the type of car rented affects the length of the rental period. An experiment is run for one week at a particular location, and 10 rental contracts are selected at random for each for car type as **Subcompact**,

#### Compact, Midsize and Full size[3 pt each]

- A) Determine and Write all treatment
  - a = 4
  - ✓ Subcompact,
  - ✓ Compact,
  - ✓ Midsize and
  - ✓ Full size
- B) Determine the observation for each treatment

✓ n = 10

C) What is the total sample size of the experiment

✓ N = an=4x10 = 40

D) State the ANOVA table

Source	DF	SS	MS	F
Treatment	3	SStr	MStr	MStr
Error	36	SSE	MSE	MSE
Total	39	SST		

3. Fifteen students took part in an experiment to assess the effect of study habits on the retention of material. Three different types of study habit were taken and the fifteen students were randomly assigned to one of these types (treatments) Each student was then assessed on his knowledge of the material by means of a multiple choice exam. Results were as follows:

Study Habit	Scores				
Control-reading only	22	30	14	28	31
Reading and summary	32	37	42	28	21
Skimming, thinking, reading	44	37	<b>48</b>	35	31

A) Does the study method affect the retention of the material? Clearly state the hypothesis and use  $\alpha = 0.05$ ? (6 Points that is 1 point for the hypothesis, 1 point for the formulas, 3 points for the calculations and 1 point for the conclusions)

**The Hypotheses:**  $\begin{array}{l}
H_{0}: \mu_{1} = \mu_{2} = \mu_{3} \\
H_{1}: \mu_{i} \neq \mu_{j} \text{ for at least one pair of } (i, j)
\end{array}$ User One-Way ANOVA where a = 3, n = 5

Study Habit	Scores				$\overline{\mathcal{Y}}_{i.}$	
Control-reading only	22	30	14	28	31	25
Reading and summary	32	37	42	28	21	32
Skimming, thinking, reading	44	37	48	35	31	39
						<i>y</i> =32

$$SS_{\text{Treatments}} = \frac{1}{n} \sum_{i=1}^{a} y_i^2 - \frac{y_{...}^2}{N}$$
$$SST = \sum_{i=1}^{a} \sum_{j=1}^{n} y_{ij}^2 - \frac{y_{...}^2}{N}$$
$$SSE = SST - SS_{\text{Treatments}}$$

One-way ANOVA: Control-reading, Reading, Skimming

Source	DF	Sum of Squares	Mean Square	F <sub>0</sub>
Factor	2	490.0	245.0	4.51
Error	12	652.0	54.3	
Total	14	1142.0		

**Reject** 
$$H_o$$
 if ( $F_0 = \frac{MS_{Treatments}}{MS_{Error}}$ ) >  $F_{\alpha, a-1, N-a}$ 

From F distribution table ;  $F_{0.05,2,12} = 3.89$ 

The null hypotheses should be rejected and can conclude that there is a significant difference on average between the scores on the different methods