SIE 330R Homework, Spring 2023

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HW 4 (Chapter 3)

Homework must be readable! Do not just send in numbers or charts. You must explain the homework answers Preferred to receive homework in Word doc format with any excel or Minitab results pasted into word document. You may choose to use pdf which is also OK.

• Homework #5 3.5, 3.7, 3.9, 3.12

3.5. The mean square for error in the ANOVA provides an estimate of

(a) The variance of the random error

(b) The variance of an individual treatment average

(c) The standard deviation of an individual observation

(d) None of the above

The mean square error (MSE) in an ANOVA provides an estimate of the variance of the error term in the model. The error term represents the variation in the data that is not explained by the independent variables or factors included in the model. Because of this definition, option (a) is the correct answer.

3.7. A computer ANOVA output is shown below. Fill in the blanks. You may give bounds on the *P*-value.

One-way ANOVA

Source	DF	SS	MS	F	P
Factor	987.71 / 246.93 = **4**	1174.24 - 186.53 = **987.71**	246.93	246.93 / 7.46 = **33.10**	FDIST (33.1,4,25) = **0**
Error	25	186.53	186.53 / 25 = **7.46**		
Total	29	1174.24			

3.9. The tensile strength of Portland cement is being studied. Four different mixing techniques can be used economically. A completely randomized experiment was conducted, and the following data were collected.

Mixing Technique	Tensile Strength (lb/in^2)			
1	3129	3000	2865	2890
2	3200	3300	2975	3150

3	2800	2900	2985	3050
4	2600	2700	2600	2765

(a) Test the hypothesis that mixing techniques affect the strength of the cement. Use $\alpha = 0.05$.

$H_0 = \mu_1 = \mu_2 = \mu_3 = \mu_4$

H_a = At least one μ differs from the others.

ANOVA Table:

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
MixMethod	3	489740.2	163246.73	12.72811	0.0004887
Residuals	12	153908.2	12825.69		

The ANOVA resulted in p=0.00049 which is <0.05. Therefore, we reject the null hypothesis and accept the alternative; mixing techniques do affect the strength of the cement.

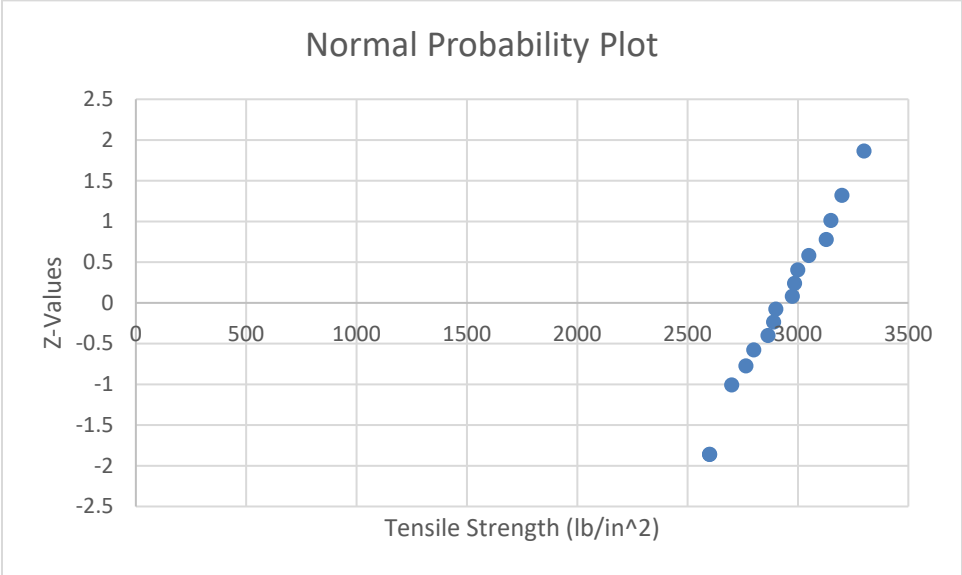
(b) Use the Tukey Pairwise Comparison method with α=0.05 to make comparisons between pairs of means.

Tuley-Kramer Pairwise Comparison					
Num df =	4	Den df =	12	Q =	4.2
Comparison	Absolute Difference	Critical Range	Results (if absolute diff > critical range, then μ's are not equal)		
μ1 to μ2	185.25	237.8261589	μ1 = μ2		
μ1 to μ3	37.25	237.8261589	μ1 = μ3		
μ1 to μ4	304.75	237.8261589	μ1 ≠ μ4		
μ2 to μ3	222.5	237.8261589	μ2 = μ3		
μ2 to μ4	490	237.8261589	μ2 ≠ μ4		
μ3 to μ4	267.5	237.8261589	μ3 ≠ μ4		

Due to absolute difference values being greater than the critical range values for the following pairs, μ1 ≠ μ4, μ2 ≠ μ4, and μ3 ≠ μ4.

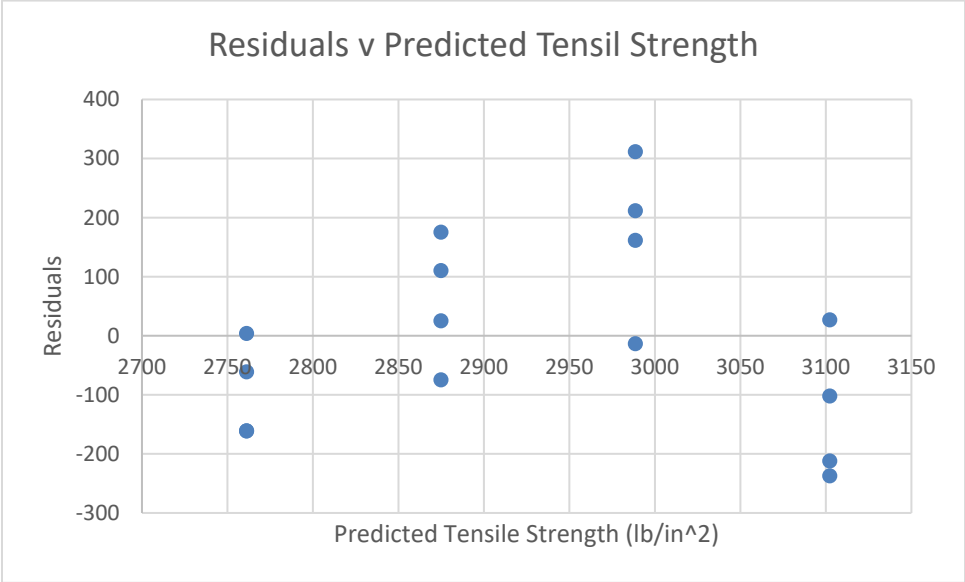
(c) Construct a normal probability plot of the residuals. What conclusion would you draw about the

validity of the normality assumption?



Because the data values in the normal probability plot fall along a roughly straight line at a 45-degree angle, we can conclude that the data is normally distributed.

(d) Plot the residuals versus the predicted tensile strength. Comment on the plot.



Based on the scatter plot above, a linear relationship analysis is not suitable.

3.12. A product developer is investigating the tensile strength of a new synthetic fiber that will be used to make cloth for men's shirts. Strength is usually affected by the percentage of cotton used in the blend of materials for the fiber. The engineer conducts a completely randomized experiment with five levels of cotton content and replicated the experiment five times. The data are shown in the following table.

Cotton Weight Percentage	Observations				
15	7	7	15	11	9
20	12	17	12	18	18
25	14	19	19	18	18
30	19	25	22	19	23
35	7	10	11	15	11

(a) Is there evidence to support the claim that cotton content affects the mean tensile strength? Use $\alpha = 0.05$.

	df	Sum of Sq	Mean Sq	F Value	P(>F)
ind	4	475.8	118.94	14.76	9.13E-06
Residuals	20	161.2	8.06		
Signify Codes:	0	0.001	0.01	0.1	1

Because …,

(b) Use the Tukey method to make comparisons between the pairs of means. What conclusions can you draw?

Based on the results of the Turkey method:

|μ15% - μ20%| = |9.8−15.4| = 5.6 > 3.713

| μ15% - μ25%| = |9.8−17.6| = 7.8 > 3.713

| μ15% - μ30%| = |9.8−21.6| = 11.8 > 3.713

| μ15% - μ35%| = |9.8−10.8| = 1.0 < 3.713

| μ20% - μ25%| = |15.4−17.6| = 2.2 < 3.713

| μ20% - μ30%| = |15.4−21.6| = 6.2 > 3.7135

| μ20% - μ35%| = |15.4−10.8| = 4.6 > 3.713

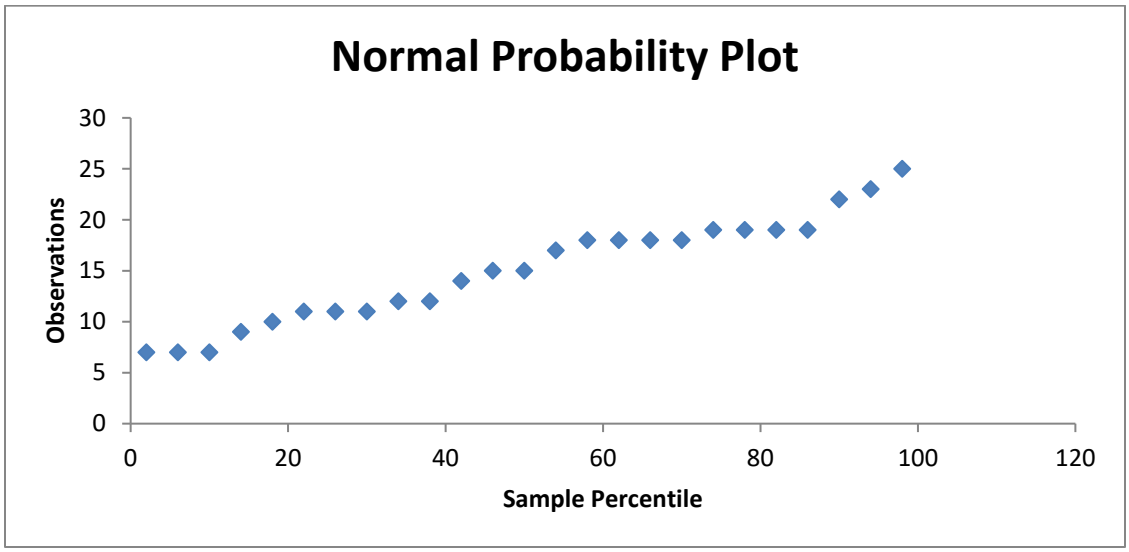
| μ25% - μ30%| = |17.6−21.6| = 4 > 3.713∗

| μ25% - μ35%| = |17.6−10.8| = 6.8 > 3.713

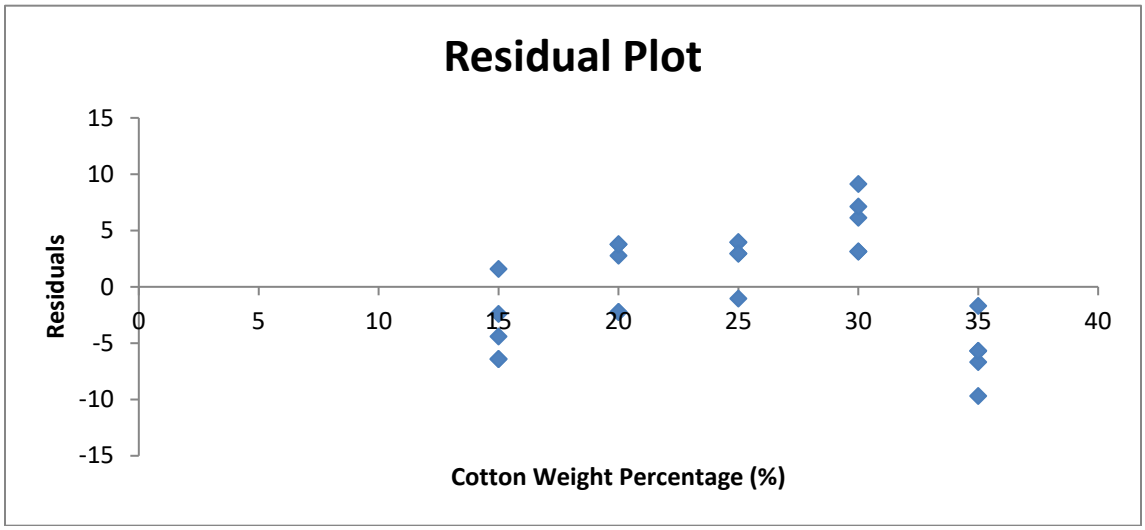
| μ30% - μ35%| = |21.6−10.8| = 10.8 > 3.713

All pairs of means are significantly different except the cotton weights with percentages of 15% vs. 35% and 20% vs. 25%.

(c) Analyze the residuals from this experiment and comment on model adequacy.



Normal probability plot is linear. Therefore, the assumption of normality holds true.



The variance (spread) of the residuals is inconsistent across the samples. Therefore, the assumption of equal error variance is not well supported.