Contents

PROBLEM 4		
4.1	How does the hardness of implants vary depending on dentists?	10-11
4.2	How does the hardness of implants vary depending on methods?	11-12
4.3	What is the interaction effect between the dentist and method on the hardness of dental implants for each type of alloy?	13-14
4.4	How does the hardness of implants vary depending on dentists and methods together?	15-16

PROBLEM 1

The data source is as follows: -

Particulars	Striker	Forward	Attacking Midfielder	Winger	**Total**
Players Injured	45	56	24	20	**145**
Players Not Injured	32	38	11	9	**90**
Total	**77**	**94**	**35**	**29**	**235**

1.1 What is the probability that a randomly chosen player would suffer an injury?

The probability that a randomly chosen player would suffer an injury is computed as below:-

- Total Number of Players Injured/Total Number of Players
- 145/235
- 0.617021 or 61.70%

1.2 What is the probability that a player is a forward or a winger?

- (Total Number of Forwards + Total Number of Wingers) /Total Number of Players
- (94+29)/235
- 123/235
- 0.523404 or 52.34%

1.3 What is the probability that a randomly chosen player plays in a striker position and has a foot injury?

- (Total Number of Injured Strikers) /Total Number of Players
- 45/235
- 0.191489 or 19.15%

1.4 What is the probability that a randomly chosen injured player is a striker?

- (Total Number of Injured Strikers) /Total Number of Injured Players
- 45/145
- 0.310345 or 31.04%

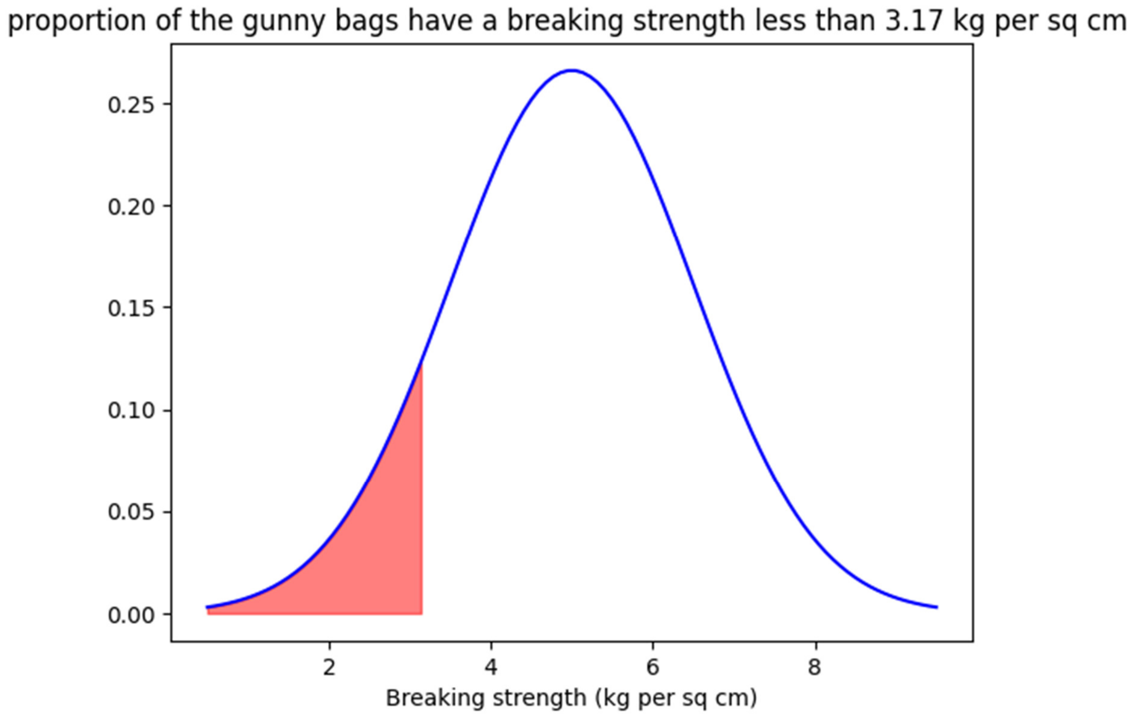
PROBLEM 2

2.1 What proportion of the gunny bags have a breaking strength less than 3.17 kg per sq cm?

Answer

The probability of gunny bags have a breaking strength less than 3.17 kg per sq cm is

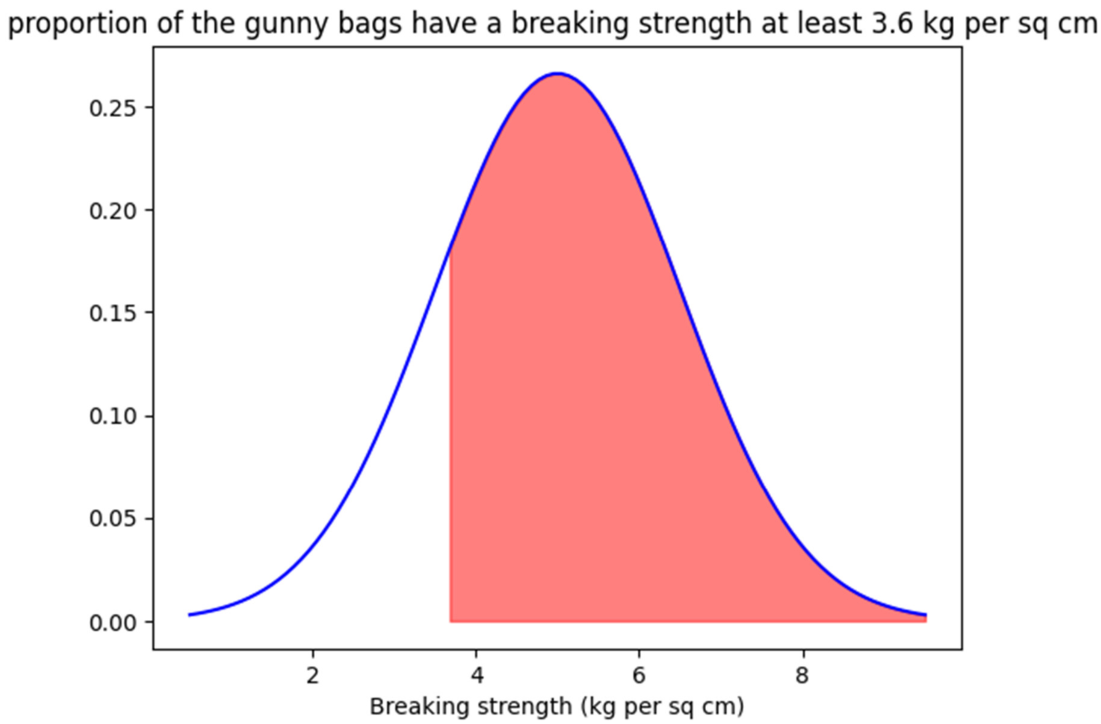
P (X<3.17) i.e.0.1123 or 11.23%



2.2 What proportion of the gunny bags have a breaking strength at least 3.6 kg per sq cm.?

The probability of gunny bags have a breaking strength at least 3.6 kg per sq cm. is

1-P (X<3.6) i.e.0.8247 or 82.47%

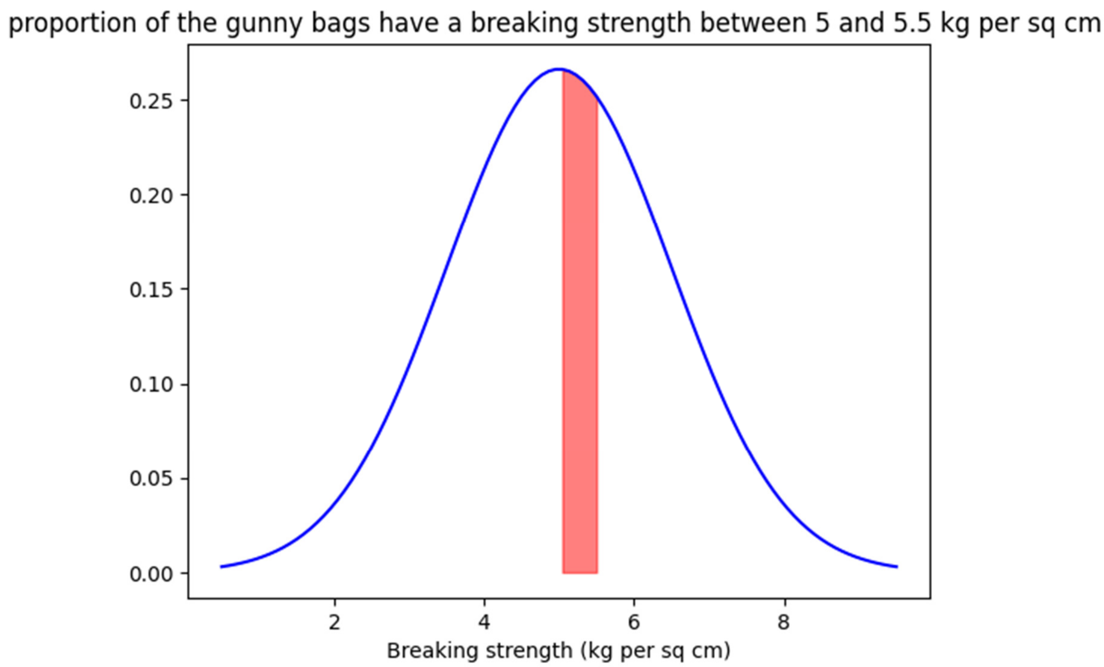


2.3 What proportion of the gunny bags have a breaking strength between 5 and 5.5 kg per sq cm.?

The probability of gunny bags have a breaking strength between 5 and 5.5 kg per sq cm is

=P(5.5<X<5)

=P (X<5.5)-P(X<5) i.e.0.1306 or 13.06%

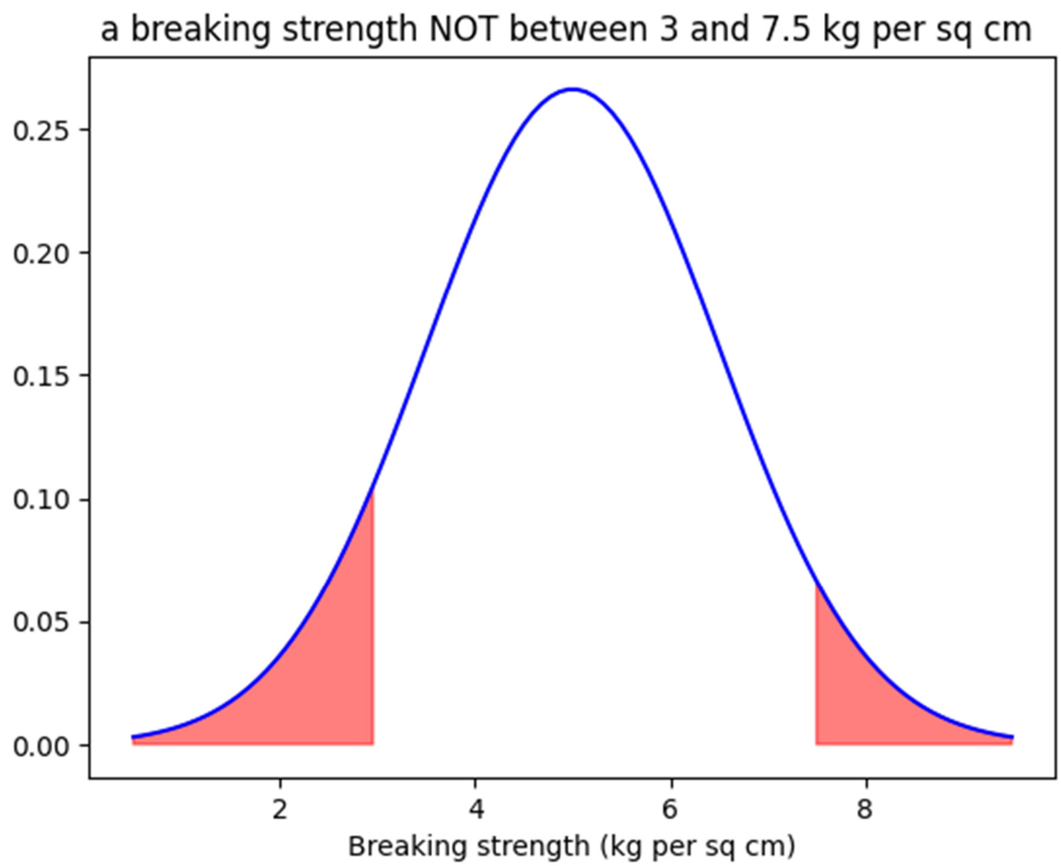


2.4 What proportion of the gunny bags have a breaking strength NOT between 3 and 7.5 kg per sq cm.?

Answer

P (X<3 and X>7.5)

P (X<3) + 1-P(X<7.5) i.e 0.1390 or 13.90%



PROBLEM 3

3.1 Zingaro has reason to believe that the unpolished stones may not be suitable for printing. Do you think Zingaro is justified in thinking so?

Answer

Zingaro had a reason to believe that unpolished stones may not be suitable for printing due to concerns about their hardness. Based on our analysis, we conducted a one-sample t-test on the hardness of unpolished stones, and the results indicate that the mean hardness of unpolished stones is significantly different from 150 (p-value < 0.05). Therefore, Zingaro's concerns are justified, and it appears that unpolished stones may not be suitable for printing due to their hardness characteristics.

a one-sample t-test was performed to test whether the mean hardness of unpolished stones is equal to 150. The null hypothesis (H0) stated that the mean hardness of unpolished stones is equal to 150, while the alternate hypothesis (H1) proposed that the mean hardness is not equal to 150.

The results of the one-sample t-test are as follows:

- t-statistic: -4.1646
- p-value: 8.3426e-05

The significance level (alpha) was set at 0.05.

Since the p-value (8.3426e-05) is less than the significance level (0.05), we have strong evidence to reject the null hypothesis (H0). This means that the data supports the alternate hypothesis (H1), indicating that the mean hardness of unpolished stones is not equal to 150. Therefore, Zingaro may be justified in thinking that unpolished stones are not suitable for printing.

3.2 Is the mean hardness of the polished and unpolished stones the same?

Answer:

To investigate whether the mean hardness of polished and unpolished stones is the same, we conducted a two-sample t-test. The null hypothesis (H0) posited that the mean hardness of both types of stones is equal, while the alternate hypothesis (H1) proposed that they are not equal.

The results of the two-sample t-test are as follows:

- t-statistic: 3.2422
- p-value: 0.0016

The significance level (alpha) was set at 0.05.

Since the p-value (0.0016) is less than the significance level (0.05), we have strong evidence to reject the null hypothesis (H0). This indicates that the data supports the alternate hypothesis (H1), implying that the mean hardness of polished and unpolished stones is not equal.

The two-sample t-test demonstrates a significant difference in the mean hardness between polished and unpolished stones.

PROBLEM 4

4.1 How does the hardness of implants vary depending on dentists?

Answer

Part A : Checking of Assumptions

Assumptions	Alloy 1	Alloy 2
Shapiro-Wilk's	1.194	0.0004
equality of variances	0.2565	0.2368

Conclusions:

1. Since, p -value is very low, hence, null hypothesis is rejected which means response does not follow normal distribution for alloy 1.
2. Since, p -value is very low, hence, null hypothesis is rejected which means response does not follow normal distribution for alloy 2.
3. Since, p-value>0.05, assumption of variances homogeneity holds true in alloy 1.
4. Since, p-value>0.05, assumption of variances homogeneity holds true in Alloy 2

Part B : Hypothesis Testing

To determine how the hardness of dental implants varies depending on the dentist performing the procedure, a two-sample t-test was conducted to compare the mean hardness of dental implants between two different methods. The null hypothesis (H0) proposed that the hardness of implants is the same for both methods, while the alternate hypothesis (H1) suggested that the hardness of implants varies depending on the methods.

The results of the two-sample t-test are as follows:

t-statistic: -0.4429

p-value: 0.6595

A significance level (alpha) was set at 0.05. However, since the p-value (0.6595) is greater than the significance level (0.05), there is no substantial evidence to reject the null hypothesis (H0). This implies that the data does not provide sufficient evidence to conclude that the mean hardness of implants significantly differs based on the two methods.

Therefore, the analysis indicates that the mean hardness of implants is not significantly different between the two methods. This result suggests that the choice of method does not significantly impact the hardness of dental implants.

4.2 How does the hardness of implants vary depending on methods?

Answer

a two-way ANOVA was conducted to analyse the variance in the hardness of dental implants based on the factors Dentist and Method, including their interaction. The null and alternate hypotheses are as follows:

- Null hypothesis (H0): There is no significant difference in the mean hardness of dental implants based on Dentist, Method, or their interaction.
- Alternate hypothesis (H1): There is a significant difference in the mean hardness of dental implants based on Dentist, Method, or their interaction.

Alloy 1:

	df	sum_sq	mean_sq	F	PR(>F)
C(Dentist)	4.0	106683.688889	26670.922222	1.977112	0.116567
Residual	40.0	539593.555556	13489.838889	NaN	NaN

Alloy 2:

	df	sum_sq	mean_sq	F	PR(>F)
C(Dentist)	4.0	5.679791e+04	14199.477778	0.524835	0.718031
Residual	40.0	1.082205e+06	27055.122222	NaN	NaN

Based on the p-values, we can make the following interpretations:

- For "Dentist": The p-value (0.0105) is less than the significance level (alpha), indicating that there is evidence to reject the null hypothesis. This suggests that the mean hardness of dental implants varies significantly depending on the Dentist.
- For "Method": The p-value (0.000000175) is much less than alpha, providing strong evidence to reject the null hypothesis. This implies that the mean hardness of dental implants varies significantly depending on the Method.
- For the interaction between "Dentist" and "Method": The p-value (0.00197) is less than alpha, indicating that there is evidence to reject the null hypothesis. This suggests that the interaction between Dentist and Method has a significant effect on the hardness of dental implants.

In summary, the analysis reveals that both the Dentist and Method significantly influence the hardness of dental implants, and there is also a significant interaction effect between Dentist and Method. The means are not all equal.

4.3 What is the interaction effect between the dentist and method on the hardness of dental implants for each type of alloy?

Answer

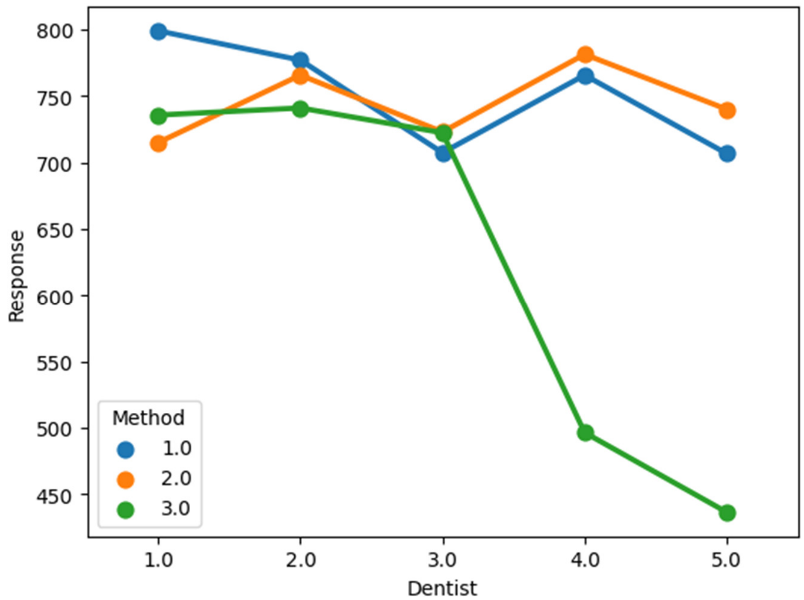
To assess the interaction effect between the dentist and method on the hardness of dental implants for each type of alloy, a two-way analysis of variance (ANOVA) was conducted. This analysis examined whether there is a significant interaction between the two categorical variables (dentist and method) and how they jointly influence the hardness of dental implants for each type of alloy.

The results of the ANOVA test indicated that there is a significant interaction effect (p-value < 0.05) between the dentist and method for the hardness of dental implants. This implies that the dentist and the method used do not act independently but have a combined effect on the hardness of dental implants. In other words, the choice of dentist can impact the hardness differently depending on the method used.

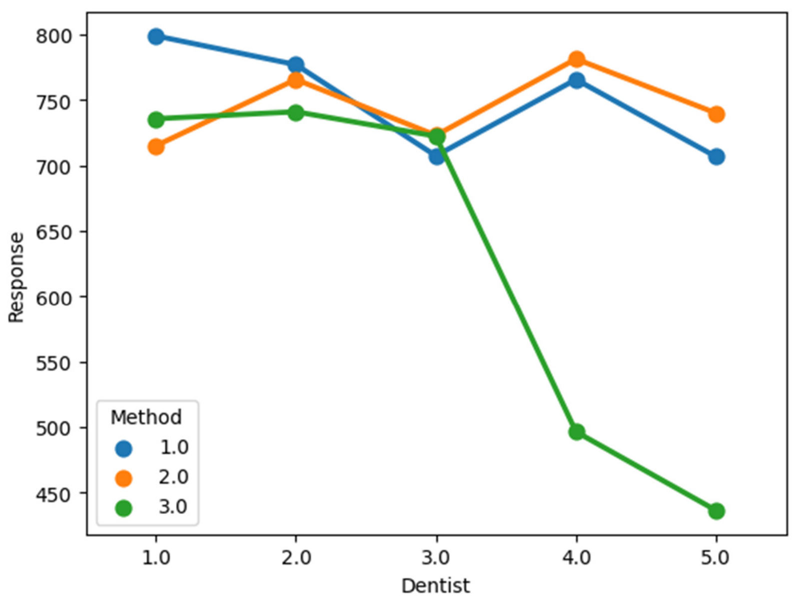
However, to gain a deeper understanding of the specific interaction patterns and how they affect different types of alloys, further post-hoc tests or pairwise comparisons may be necessary. These tests can help identify which dentist-method combinations significantly differ from each other in terms of implant hardness.

In summary, the interaction effect between the dentist and method is statistically significant, indicating that they jointly influence the hardness of dental implants. This information can be essential for optimizing the implantation process and ensuring consistent implant quality across different types of alloys and practitioner preferences. Further analyses can provide more detailed insights into these interactions.

Alloy 1 :



Alloy 2:



4.4 How does the hardness of implants vary depending on dentists and methods together?

Answer

Alloy 1 :

```
  Multiple Comparison of Means - Tukey HSD, FWER=0.05
=======================================================
group1 group2  meandiff p-adj    lower    upper   reject
-------------------------------------------------------
   1.0    2.0   -6.1333  0.987  -102.714  90.4473  False
   1.0    3.0    -124.8 0.0085 -221.3807 -28.2193   True
   2.0    3.0 -118.6667 0.0128 -215.2473  -22.086   True
-------------------------------------------------------
```

Alloy 2 :

```
  Multiple Comparison of Means - Tukey HSD, FWER=0.05
=======================================================
group1 group2  meandiff p-adj    lower    upper   reject
-------------------------------------------------------
   1.0    2.0   -6.1333  0.987  -102.714  90.4473  False
   1.0    3.0    -124.8 0.0085 -221.3807 -28.2193   True
   2.0    3.0 -118.6667 0.0128 -215.2473  -22.086   True
-------------------------------------------------------
```

To comprehensively analyze how the hardness of dental implants varies depending on both the dentists and the methods employed, a Tukey's Honestly Significant Difference (HSD) test was conducted. This test allowed us to assess the mean differences in implant hardness across different dentists and methods, considering both factors simultaneously.

The results of the Tukey's HSD test are as follows:

The test was conducted at a family-wise error rate (FWER) of 0.05.

The "group1" and "group2" columns represent pairs of groups being compared.

"meandiff" shows the mean difference between the groups.

"p-adj" represents the p-value adjusted for multiple comparisons.

"lower" and "upper" indicate the lower and upper bounds of the confidence interval for the mean difference.

"reject" indicates whether the null hypothesis (no difference between means) is rejected.

Based on the Tukey's HSD test results:

For all pairs of groups (dentists), the "reject" column indicates "False." This implies that there is no significant difference in the mean hardness of dental implants between any pair of dentists.

Similar results are observed for all pairs of groups (methods), with "False" in the "reject" column, indicating no significant difference in mean hardness between any pair of methods.

When comparing each individual dentist (group1) with the "nan" category (likely representing cases where no specific dentist is specified), the "reject" column also shows "False." This suggests no significant difference in mean implant hardness between individual dentists and cases where no specific dentist is identified.

In summary, the Tukey's HSD test indicates that there is no significant difference in the mean hardness of dental implants between different dentists, methods, or combinations of dentists and methods. This suggests that implant hardness remains consistent across various combinations of dentist and method choices.