Question 1 - Short Questions

(i) (4 marks) What is meant by the sampling distribution of the mean? Provide a hypothetical example in your explanation.
Need to show the two formulas for the mean and the standard deviation and some explanation about it being the mean of the distribution of means.

(ii) (4 marks) What is a trimmed mean? In what circumstances would you use this measure in preference to the arithmetic mean?
Removing a percentage of the data items from each end of the distribution and then re calculating the mean. Can be used to see the effect of outliers

(iii) (4 marks) What information does a 95% confidence interval for the mean give us?
In repeated sampling you are confident that the true mean will be contained in that interval 95% of the time

(iv) (4 marks) What is a Type I error and a Type II error?
Type I error:
When the null hypothesis is true and you reject it, you make a type I error. The probability of making a type I error is α, which is the level of significance you set for your hypothesis test.
Type II error:
When the null hypothesis is false and you fail to reject it, you make a type II error. The probability of making a type II error is β, which depends on the power of the test.

(v) (4 marks) What are the tests that you can perform when comparing two populations?
Discussion of material on any two of the three tests from Unit 7.4. 2 Marks per Test

(vi) (4 marks) What are the key components that need to be identified when designing an experiment? **The following are the components of an experimental design: (1) An experimental unit is an individual object from the sample from which you obtained some measurement. (2) A factor is some variable whose value is controlled by the experimenter. (3) A level is the intensity setting of a factor. (4) A treatment is a combination of factor levels. (5) A response is the variable being measured by the experimenter.**
(1 Mark for any 4)

(vii) (4 marks) What distinguishes a factorial experiment from a completely randomised experiment or a randomised block experiment?

If there is interaction, then the other source of variation becomes a factor and possible interaction between factors must be included

in the experimental design. The type of design that allows for interaction is an a x b Factorial Experiment. This design is classified as two-way.

(viii) (4 marks) What is the difference between a "between treatments" estimate and a "within treatments" estimate?

Between treatments; variability among sample means. within treatment; variability of the data within the sample.

(ix) (4 marks) What is meant by multicollinearity? Describe some of the indicators of multicollinearity.

Multicollinearity may occur if there is a significant correlation between 2 or more of the independent variables. It often explains why a model that appears to make sense does not produce the desired results.
The following are indicators that your regression model is likely to exhibit multicollinearity during your analysis: The value of the R-sq is large indicating a good fit, but the individual t-tests are not significant.
The signs of the regression coefficients are not what you would have expected them to be; that is, contributing negatively rather than positively. A matrix of correlations generated by Minitab shows that some of the independent (predictor) variables are highly correlated.

(x) (4 marks) How does stepwise regression work and why would you use it?
Stepwise Regression is a variable selection procedure, provided as a built-in function in Minitab and it fits a variety of models to the data, adding and deleting variables based on their significance in relation to other variables in the model. It does this over a number of iterations until all significant variables have been added to the model.

(xi) (4 marks) In the context of analyzing categorical data, what is a Goodness of Fit test?
The goodness of fit test is based on comparing the observed results with the expected results, to see if there is any significant difference. The expected results are the results you would expect to see if the null hypothesis were true.

(xii) (4 marks) State the purpose of the Mann-Whitney U Test and the Kruskall Wallis Test. Include in your answer comparisons to the parametric counterpart to these tests.
The Mann Whitney U test is an alternative to the independent 2-sample t test and does not rely on normality or homogeneity of variance assumptions. The test is based on the ranking of data. It is as powerful as the t test.
The non-parametric equivalent of the F test is the Kruskal-Wallis

test. This test is also based on ranking the data. It uses the chi-squared statistic rather than the F test to calculate probabilities. The null and alternative hypotheses are the same as for the ANOVA.

Question 2 - Exeprimental Design

Part A

- The student must demonstrate a level of understanding.
- It is not enough to just state the P value. The argument must follow the correct steps as set out and both p value and confidence interval should be referred to as evidence.
- Definite statement of Null and Alternative Hypothesis for both tests
- Risk Criteria
- Decision Criteria
- Conclusion

Part B

- The student must demonstrate a level of understanding.
- It is not enough to just state the P value. The argument must follow the correct steps as set out and both p value and confidence interval should be referred to as evidence.
- Definite statement of Null and Alternative Hypothesis for both tests
- Risk Criteria
- Decision Criteria
- Conclusion

Question 3 - Normal Distribution

Part A

Marking Scheme:

- 4 Marks for showing the relevant calculations,
- 1 Mark for drawing the boxplots to a satisfactory standard.
- 1 Mark for a well-explained conclusion,

Part B

Variable X : Not Normally Dsitributed

- Histogram doesnt align well with density curve. Density curve is centred.
- QQ plot : Dots dont follow the trend line
- Boxplot is not symmetric
- Anderson Darling Test has significant result

Variable X : Normally Dsitributed

- Histogram align reasonable well with density curve. Density curve is centred.
- QQ plot : Dots mostly follow the trend line
- Boxplot is symmetric
- Anderson Darling Test does not have significant result

Part C

Part 1

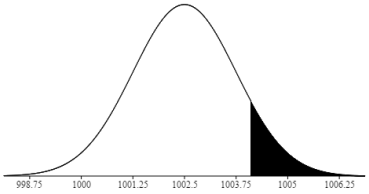
- Z score

$$z = \frac{x - \mu}{\sigma} = \frac{1004.1 - 1002.5}{1.25} = \frac{1.6}{1.25} = 1.28$$

- Using Murdoch Barnes Tables

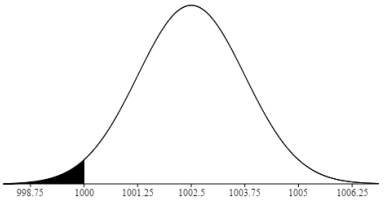
$$P(Z \geq 1.29) = 0.1003$$

- Answer: $P(X \geq 1004.1) = 0.1003$



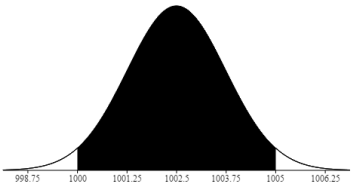
Part 2

- Z score
$$z = \frac{x - \mu}{\sigma} = \frac{1000 - 1002.5}{1.25} = \frac{-2.5}{1.25} = -2$$
- Symmetry Rule
$$P(Z \leq -2) = P(Z \geq 2)$$
- Using Murdoch Barnes Tables
$$P(Z \geq 2) = 0.02275$$
- Answer: $P(X \leq 1000) = 0.00275$



Part 3

- Z score
$$z = \frac{x - \mu}{\sigma} = \frac{1005 - 1002.5}{1.25} = \frac{2.5}{1.25} = 2$$
- Using Murdoch Barnes Tables
$$P(Z \geq 2) = 0.02275$$
- From Before $P(X \leq 1000) = 0.00275$
- Probability of being outside the interval
$$P(X \leq 1000) + P(X \leq 1000) = 2 \times 0.02275 \approx 0.0455$$
- If 99% within interval, then only 1% outside interval
- Therefore we conclude that the Claim is false



Question 4

Part A - Two Sample Test

Suppose a company manufactures a particular product in two facilities: Factory A and Factory B. The management wants to make sure that the Factory B, which has been recently constructed, is manufacturing components to the same specifications as Factory A.
Measurement data from both factories has been compiled and analysed, with the following Minitab output has been created.
Key Conclusions

- Significant Difference in Means
- Significant Difference in Variances
- Processes in both factories not working to same specification
- Equipment in Factory B needs to be re-calibrated.

Part B - Chi Square

1. Evidence that demonstrates a clear understanding of the test and its outcomes.
2. Expected Values
$$\frac{\text{Row Total} \times \text{Grand Total}}{\text{Grand Total}}$$
3. Degrees of Freedom = 4 i.e. (r-1) x (c-1)
4. Good interpretation of the data from the table combined with the correct statistical analysis. Comment on the significance of a p value being less than 0.05. There is no association..There is association.

Question 5: Regression Analysis

Part A - Simple Linear Regression Analysis

1. 3 marks for each correct value (4 for correct p-value)

$$\frac{1.016}{0.790} = 1.29$$

$$\frac{x}{0.790} = 5.61 \therefore x = 0.3640$$

2. Statement and Interpretation of the regression line

$$Tensile = 1.016 + 0.364Knots$$

3. Noting the relationship was significant

4.

$$Tensile = 1.016 + 0.364 \times 10$$

5. Stating and interpreting the R squared value

Part B - Residuals

Minitab can provide four diagnostic plots to help you appraise the quality of a linear model. What is the purpose of the diagnostic plots and what does each one tell you?

Checking for Normality of Residuals $\times 2$, Heteroscedascity, Autocorrelation

Part C - MLR

- Short Discussion / Interpretation of the regression line
- Noting the significant and non significant relationships
- Stating and interpreting the R squared value
- A discussion about the possibility of the presence of multicolinearity and the possible use of stepwise regression to eliminate it