

University of Wales Trinity Saint David
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Analysis of Student Grades Using
Statistical Methods in
MATLAB
Engineering Applications and Study Skills
ACMA4007

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1 Abstract

During this report, we will be discussing the statistical methods used to analyse student grades using various methods of analysis. Information regarding the students will be interpolated into the various types of analysis along with their grades to obtain insights into the students' performance.

2 Introduction

The brief states that we must input a series of statistics into MATLAB and extract different sets of results whilst arranging them into a table, once that is done correlation analysis and visualisation will be performed to further understand and compare the results.

The information given to us was an Excel spreadsheet displaying the student ID, Gender, Age, Attendance, Exam 1 Results and Exam 2 Results of 100 students. These results were interpolated into MATLAB to produce a table displaying the Mean, Median, Mode, Range and Standard Deviation of all figures displayed in the Excel spreadsheet.

From there a correlation analysis will be performed to determine the key performance comparisons between multiple variables, this will assist the reader in gaging a greater depth of understanding into the correlation between several numerical factors. The correlation matrix will be plotted and relationships will be identified.

The correlation matrix will be followed by a hypothesis test deriving from the data extracted from the table, it will provide insight into the null hypothesis that the two data samples are from populations with equal means.

3 Importation of Data

For this experiment the dataset provided was a Microsoft Excel spreadsheet displaying various categorial and numerical variables of 100 students. Each student was given a unique Student ID for easy identification which was proceeded by their gender, these made up the categorial variables. Further information for each student included the Ages, Attendance, Exam 1 Results and Exam 2 Results which made up the numerical values to which we will perform several experiments to further understand each student's performance.

```
A = readtable ("student_grades.xlsx");
```

Figure 1: Excel File Inserted into MATLAB

Variable	Mean	Median	Mode	Range	Standard Deviation
{'Age' }	36.65	37.5	48	34	9.7643
{'Attendance' }	60.58	57	27	80	24.249
{'1st Exam Score' }	58.27	58	59	91	21.673
{'2nd Exam Score' }	55.08	53.5	51	94	22.428
{'0/All Score' }	56.675	54.5	25.5	85.5	21.452

Figure 2: Table Produced by MATLAB

The information will be imported into the MATLAB window as shown in Figure 1, from here the information will be interpolated and manipulated by a series of commands in which a table will be created as displayed in Figure 2. This table will be a result of running commands in MATLAB through the interpolation of given data into specific equations as seen in Figure 3.

```
7 % Question B
8 B = A(:,3:6);
9 OvrScore = (B(:,3) + B(:,4))/2;
10 A("Overall Score") = OvrScore;
11 Tot = [B OvrScore];
12 Mean = (sum(Tot)./100);
13 Median = median(Tot);
14 Mode = mode(Tot);
15 Min = min(Tot);
16 Max = max(Tot);
17 R = [Min' Max'];
18 R2 = Max-Min;
19 Standard.Dev = std(Tot);
20 % Question C
21 Vars = {'Age' 'Attendance' '1st Exam Score' '2nd Exam Score' '0/All Score'};
22 VN = {'Variable' 'Mean' 'Median' 'Mode' 'Range' 'Standard Deviation'};
23 T = table (Vars',Mean',Median',Mode',R2',Standard.Dev', 'VariableNames',VN);
24 disp(T)
```

Figure 3: Equations to Create a Table

Pictured in Figure 3 is the equations used to create the table displayed in Figure 2. Line 8 shows a command to which the four relevant numerical variables (Age, Attendance, Exam 1 score, Exam 2 score) will be extracted as a matrix, the mean of the scores will then be calculated in line 9 and imported into tabular form in line 10. From there all numerical data

will be exported into a matrix and solved for the Mean, Median, Mode, Range and Standard Deviation as solved in Figure 3 and displayed in Figure 2.

Lines 21 to 24 in Figure 3 will give the structure of the table seen in figure 2. Line 21 is designed to portray the cell array of row titles and line 22 portrays the cell array of column titles, they are then merged into a table and printed out in the command window by the two following lines.

Summary statistics are an effective way of summarising a set of variables as simply as possible, they can observe a large pool of statistics efficiently which makes them an effective of tool for organisations, they do however come with setbacks.

Summary statistics can struggle to accurately interpret data in meaningful ways which can lead to inaccuracies and difficulty drawing conclusions, not to mention they are susceptible to errors and bias.

The first limitation of summary statistics is the sample size, you must obtain results from a large enough sample to create a valid hypothesis once data has been collected, this can cause the results to not be representative of the entire population which will draw inaccurate hypotheses.

Other limitations include bias of data, for example, “if a sample is composed of only one gender or age group, the results may not be applicable to the population as a whole.” (Limitation of Statistics, Victor R.).

4 Correlation Analysis

The statistical technique of correlation analysis is used for determining how closely linked two variables are, it is commonly used to identify patterns and trends in data and predicts future occurrences (GeeksforGeeks, 2023).

Correlation Coefficient Formula

$$r = \frac{n(\sum xy) - (\sum x)(\sum y)}{\sqrt{[n\sum x^2 - (\sum x)^2][n\sum y^2 - (\sum y)^2]}}$$

Figure 4: Correlation Coefficient Equation (BYJUS, n.d.)

The correlation coefficient denoted by “r” is ranged from -1 to +1. A correlation coefficient of $r = -1$ indicates a perfect negative correlation, and a value of $r = 1$ gives a perfect positive coefficient, whereas a value of $r = 0$ indicates there is no linear correlation between variables. The correlation coefficient formula is denoted in Figure 4 and displays the method of how the correlation coefficient is calculated.

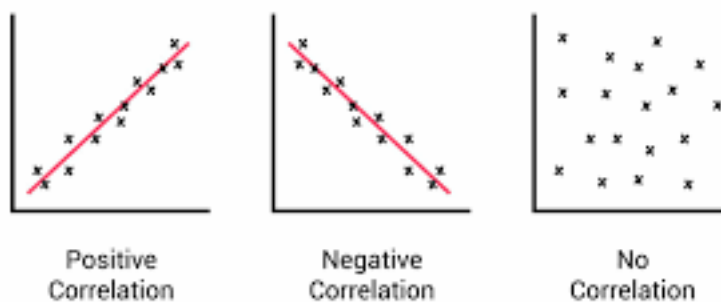


Figure 5: Correlation Matrix Graphs (Mcleod, 2023)

The three graphs in Figure 5 visualise the different types of correlation analysis. Graph 1 portrays a positive correlation ($r = 1$) meaning a relationship has a direct relationship indicating as one variable increases the other increases. Graph 2 of Figure 5 is the visualisation of a negative correlation ($r = -1$) indicating an inverse relationship, so as one variable may increase, the other will decrease. Thirdly, the final graph of Figure 5 displays no correlation ($r = 0$) indicating each variable has no relationship. A correlation matrix visualisation has been created for the dataset

MATLAB was used to create a matrix of the pairwise linear correlation coefficients between the four cell array rows pictured in figure 2, these were performed through using the function ‘corr’ and further analysed through the function ‘ttest2’.

/MATLAB Drive/Assignment.m

```
29 % Question A
30 C = corr(Tot);
31 disp(C)
32
33 % Question B
34 VN2 = {'Age' , 'Attendance' , 'Exam 1' , 'Exam 2' , '0/All Score'};
35 figure(1)
36 corrplot(Tot, 'VarNames' , VN2 , 'TestR' , 'on');
37
38 % Question C
39 Male_Key = A.gender == ("Male");
40 Female_Key = A.gender == ("Female");
41 Male_Data = A(Male_Key,:);
42 Female_Data = A(Female_Key,:);
43 Exam1M = Male_Data(:,5);
44 Exam1F = Female_Data(:,5);
45 Exam2M = Male_Data(:,6);
46 Exam2F = Female_Data(:,6);
47 Exam0M = Male_Data(:,7);
48 Exam0F = Female_Data(:,7);
49 [h(1),p(1)] = ttest2(Exam1M,Exam1F);
50 [h(2),p(2)] = ttest2(Exam2M,Exam2F);
51 [h(3),p(3)] = ttest2(Exam0M,Exam0F);
52 disp(h)
53 disp(p)
54
```

Figure 6: Commands Used to Create a Correlation Matrix

The command/function 'corr' is finding correlation coefficients by running a test between all columns of data (i.e., Age vs Exam 1 scores, Attendance vs Overall Score, etc.), columns are also run in a test against themselves which returns a value of 1 (a positive correlation). The test being run here is to check for linear correlation and return a value of how strong it is (1 being directly proportional), this can be plotted with the command 'corrplot' and the coefficients are listed on the graphs as shown in line 30 of Figure 6.

Command Window

1.0000	-0.0362	-0.0364	-0.0506	-0.0448
-0.0362	1.0000	0.8912	0.8297	0.8839
-0.0364	0.8912	1.0000	0.8929	0.9719
-0.0506	0.8297	0.8929	1.0000	0.9738
-0.0448	0.8839	0.9719	0.9738	1.0000

0 0 0

0.3790 0.5242 0.4370

>> |

Figure 7: Correlation Matrix

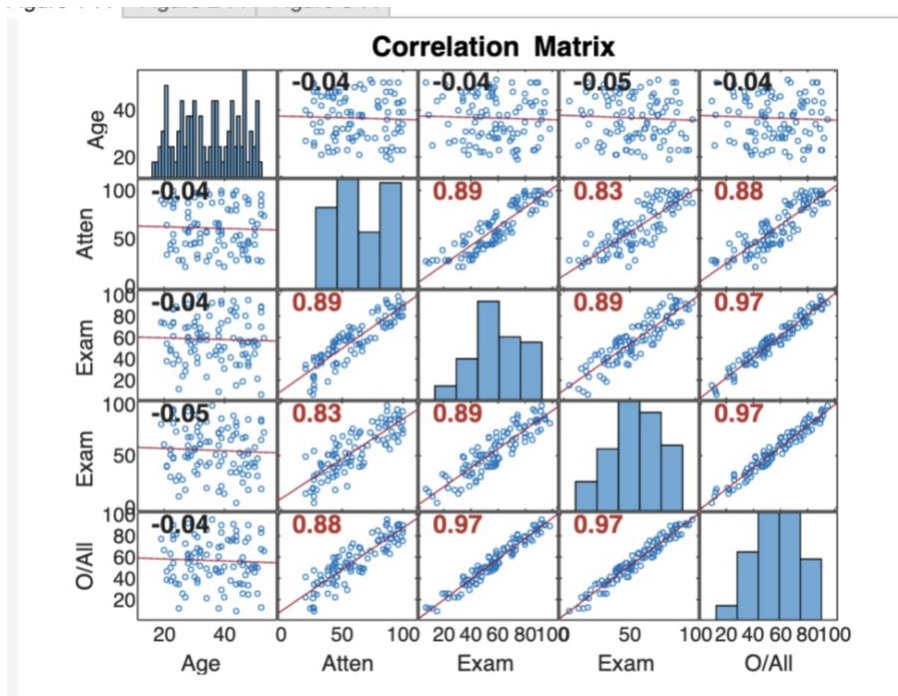


Figure 8: Visualisation of the Correlation Matrix

Pictured in Figure 7 is the results from the 'corr' function performed in MATLAB, it displays an array of correlations in relation to the collated data in Figure 2. This is followed by the visualisation in Figure 8 which corresponds directly to the output of Figure 7.

The absolute positive correlations ($r = 1$) are shown when the matrix displays the same set of data (Exam 1 vs Exam 1), which is visualised with a histogram. These figures should be ignored due to their lack of significance. Another thing to note is the lack of negative correlations ($r = -1$), which is expected in this type of experiment, therefore the areas of significance will be the zero/low correlations and positive correlations.

The areas of little/no correlation appear most commonly when age is factored in, with r values ranging between -0.05 and 0.04. The hypothesis gathered from this set of correlative data implies age is of low significance when factoring exam results and attendance, this will rule out any variation amongst age groups when analysing performance.

Further examination of the correlation matrix performed from the dataset points to a strong positive correlation between attendance and exam scores. The student attendance vs O/All exam score produces a correlation coefficient value of 0.88 which infers a strong linear relationship between the points, which solidifies the hypothesis of high attendances contributing to greater exam performance.

The final correlation to discuss is the correlation between the exam scores, each exam score (first and second) equals a correlation coefficient of $r = 0.89$ showing there is very little variance in scores for each exam. The hypothesis created from this value indicates students performed equally as well on each exam, meaning insignificant variation was present in the difficulty of each exam. These factors can be validated by the correlation coefficient of $r = 0.97$ for the O/All score against individual exam scores, which portrays a near linear correlation between the values ($r = 1$ being perfectly linear).

The 'corr' command is followed by a hypothesis test, the command for this is denoted as 'ttest2' which will test a null hypothesis that two independent samples come from distributions with equal means (unpaired test) therefore, h is binary 1 (true) or 0 (false). The definition of how 'ttest2' behaves is explained in the following passage from the MathWorks website; "ttest2(x,y) returns a test decision for the null hypothesis that the data in vectors x and y comes from independent random samples from normal distributions with equal means and equal but unknown variances, using the [two-sample t-test](#). The alternative hypothesis is that the data in x and y comes from populations with unequal means. The result h is 1 if the test rejects the null hypothesis at the 5% significance level, and 0 otherwise." (uk.mathworks.com, n.d.).

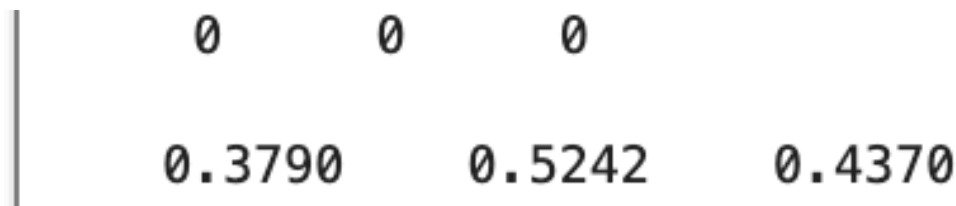


Figure 9: Hypothesis Test Results

Pictured in Figure 9 is the results of the hypothesis test run from the command "ttest2", this tests the null hypothesis where $h = 1$ is true and $h = 0$ is false. As seen above, the code has returned zeros for all tests meaning they do not share the same mean thus indicating gender has no overriding significance on the exam scores.

The P-value is a measure of whether a test is statistically significant, it is a value between 0 and 1. Typically, it is taken as a value less than 0.005 means the "test" hypothesis is correct. Despite this, it is commonly misused as it is a simplistic description that isn't always correct.

5 Visualisation of grouped Data

The two types of data visualisation for Exam 1, Exam 2 and O/All results are histograms and ogives. These will be deduced to understand the correlation between the numerous sets of results and how they can be broken down into simpler terms. The grouping of data provides a clearer understanding into what the statistics are trying to represent, making analysis easier and more efficient.

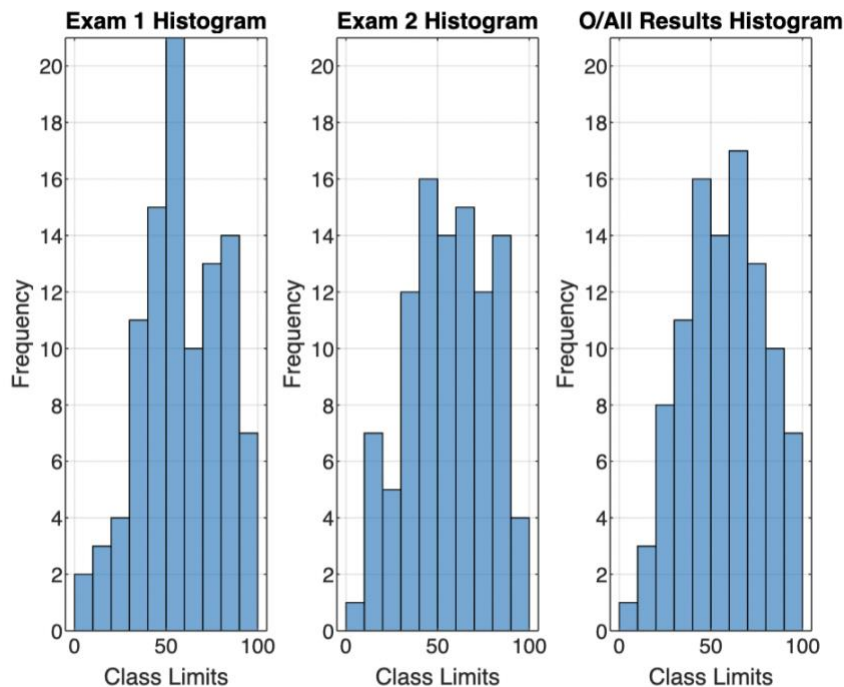


Figure 10: Histogram of Grouped Data

```

58 % Question A
59 [Bin1,Edges1] = histcounts(A(:,5),0:10:100);
60 [Bin2,Edges2] = histcounts(A(:,6),0:10:100);
61 [Bin0,Edges0] = histcounts(A(:,7),0:10:100);
62 Ymax = max([Bin1,Bin2,Bin0]);
63
64 % Question B
65 figure(2)
66 subplot(1,3,1)
67 histogram(A(:,5),Edges1)
68 grid on
69 xlabel('Class Limits')
70 ylabel('Frequency')
71 ylim([0,Ymax])
72 title('Exam 1 Histogram')
73 subplot(1,3,2)
74 histogram(A(:,6),Edges2)
75 grid on
76 xlabel('Class Limits')
77 ylabel('Frequency')
78 ylim([0,Ymax])
79 title('Exam 2 Histogram')
80 subplot(1,3,3)
81 histogram(A(:,7),Edges0)
82 grid on
83 xlabel('Class Limits')
84 ylabel('Frequency')
85 ylim([0,Ymax])
86 title('O/All Results Histogram')
87

```

Figure 11: MATLAB Input to Produce Histogram

The first example of grouped data is the input of a histogram as shown in Figure 10. As seen in Figure 11 it was initially calculated by using the function 'histcounts' which collects and

arranges the data ready for plotting, from there the function 'histogram' visualises the data against a set of axes, in this case frequency against class limits.

The histogram provides an insight into the frequency of different exam scores in the class, in this case we observe a high frequency of scores between the 40%- and 60%-mark but a far lower frequency at both the high and low extremes. This will point to a far class average mark of the mid-range; however, this type of data collection is limited to what it can represent.

Histograms are too dependent on the number of bins, meaning it is difficult to specifically pinpoint certain datum points across the dataset making analysis less accurate. Histograms are best used when analysing continuous or numerical data which has a single peak or mode (e.g height, weight, temperature), not categorical data which multiple modes such as gender or rating (in this case, exam score). (www.linkedin.com, n.d.).

The second type of grouping data is the ogives plot, the definition of an ogive is “an Ogive is a graph that represents the frequency distribution of a data series. It is a graph of cumulative distribution, which plots data values on the horizontal axis and cumulative frequencies, cumulative relative frequencies, or cumulative percent frequencies on the vertical axis.” (Testbook, n.d.).

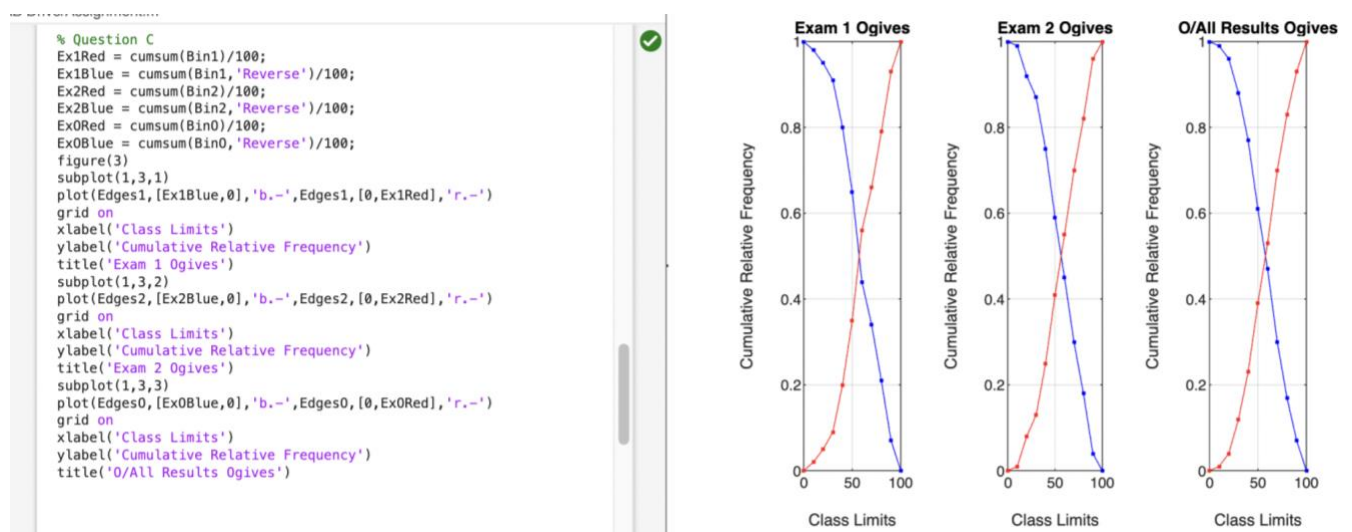


Figure 12: Ogive Function and Plot

Figure 12 presents the second part of the grouped data, displaying an ogive curve for the cumulative frequency of both exams and the overall results.

The ogive is a useful way of grouping data, and certainly more useful than a histogram due to it being a useful way of estimating the number of observations that are less than or equal to a particular value. (BYJUS, n.d.). In this example, the blue line is representative of the less than ogive and the red line is representative of the greater than ogive, these intersect on the graph to create to indicate the exact centre point of the cumulative frequency as well as present quartile and percentile indicators.

Despite ogives being an effective tool in grouping cumulative data, they do come with their limitations. Ogives are not representative of all data points due to only the class boundaries being plotted on the x-axis. This in summary means the data between points does not contribute to constructing the ogive. In addition to this limitation, ogives also fail to reveal anything about central tendency and dispersion which gives less information to summarise in this experiment.

6 Conclusion

To conclude this report, the key findings will be discussed along with the implications that have been identified through conducting experiments with the dataset.

Firstly, the importation of data provided a base set of information to perform comparative experiments with, getting the code correct for this was vital to ensuring the correlation analysis and hypothesis test was correct. The commands seen in Figure 2 created the matrix seen in Figure 3 which gave the correct data to manipulate for the tests to follow.

The importation of data was followed by a correlation analysis which tested how closely related different factors of numerical information are. The plot depicted in Figure 8 concluded that age had very little correlation with the exam scores or attendance, but attendance was very closely correlated to exam performance. However, the most closely correlated pieces of information were the Exam 1 and Exam 2 scores indicating a small variance in difficulty between the two. A small limitation of the correlation analysis is the fact it assumes that all observations are independent of each other. (Ranganathan and Aggarwal, 2016).

Hypothesis tests were carried out to prove the significance of exam results between genders using the function 'ttest2', this tested the null hypothesis that the two data samples were from populations with equal means (male and female). The corresponding result returned a null hypothesis for all three exams, meaning a p value of 0 for each returning a FALSE statement. The result of this hypothesis indicated very no correlation between gender and exam performance.

The final part of the report focused on grouping the data into a histogram and an ogive. The histogram provided a clear layout to assist the reader in understanding the frequency of data for each exam, it did however come with drawbacks. The histograms were dependant on the number of bins so identifying specific data points was difficult, meaning data can only be reviewed broadly.

The second visualisation was a series of ogive plots, these plots provided the reader with "more than" and "less than" figures into the frequency of data, creating an intercept at the centre mark. The ogives were also useful for identifying specific datum points on the graph, such as quartiles and percentiles. Ogives were not perfect however, they only represented accurate information for given data points and not the data in-between them.

7 References

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www.linkedin.com. (n.d.). *What are the limitations of using histograms for problem analysis?* [online] Available at: <https://www.linkedin.com/advice/0/what-limitations-using-histograms-problem-analysis>.

8 Appendix

clc

clear

close all

format short

% Question A

A = readtable ("student_grades.xlsx"); %Import data from Excel file
as table

% Question B

B = A{:,3:6}; %Extract Age, Attendance, and Exam

Scores as Matrix

OvrScore = (B(:,3) + B(:,4))/2; %Calculate Mean of Scores

(Overall Score)

A("Overall Score") = OvrScore; %Import Overall Score into

Tabulated Data

Tot = [B OvrScore]; %Extract All Numeric Data as Matrix

Mean = (sum(Tot)./100); %Calculate Mean of Datasets

Median = median(Tot); %Calculate Median of Datasets

Mode = mode(Tot); %Calculate Mode of Datasets

Min = min(Tot); %Calculate Minimums of Datasets

Max = max(Tot); %Calculate Maximums of Datasets

R = [Min' Max']; %Store Minimums and Maximums as

Matrix

R2 = Max-Min; %Calculate Range of Datasets

Standard.Dev = std(Tot); %Calculate Standard Deviations
of Datasets

% Question C

Vars = {'Age' 'Attendance' '1st Exam Score' '2nd Exam Score' 'O/All Score'}; %Cell Array of
Row Titles

VN = {'Variable' 'Mean' 'Median' 'Mode' 'Range' 'Standard Deviation'}; %Cell Array of
Column Titles

T = table (Vars',Mean',Median',Mode',R2',Standard.Dev','VariableNames',VN); %Create
Table of Statistical Data

```

disp(T)                                %Print Table to Command Window

% Part II

% Question A
C = corr(Tot);                          %Calculate Pairwise Linear Correlation
Coefficients Matrix
disp(C)                                %Print Coefficients Matrix to Command
Window

% Question B
VN2 = {'Age' , 'Attendance' , 'Exam 1' , 'Exam 2' , 'O/All Score'};          %Cell Array of
Correlation Titles
figure(1)                              %Initialise Figure
corrplot(Tot, 'VarNames' , VN2 , 'TestR' , 'on');                          %Produce Correlation Plot
of Data

% Question C
Male_Key = A.gender == ("Male");        %Create Binary Key of "Male"
Data
Female_Key = A.gender == ("Female");    %Create Binary Key of
"Female" Data
Male_Data = A(Male_Key,:);              %Extract Male Data as Cell
Array
Female_Data = A(Female_Key,:);          %Extract Female Data as
Cell Array
Exam1M = Male_Data{:,5};                 %Convert Data to Matrix
Exam1F = Female_Data{:,5};              %Convert Data to Matrix
Exam2M = Male_Data{:,6};                %Convert Data to Matrix
Exam2F = Female_Data{:,6};              %Convert Data to Matrix
ExamOM = Male_Data{:,7};                 %Convert Data to Matrix
ExamOF = Female_Data{:,7};              %Convert Data to Matrix
[h(1),p(1)] = ttest2(Exam1M,Exam1F);     %Run Test for First Exam
[h(2),p(2)] = ttest2(Exam2M,Exam2F);     %Run Test for Second
Exam

```

[h(3),p(3)] = ttest2(ExamOM,ExamOF);	%Run Test for Overall
Score	
disp(h)	%Print to Command Window
disp(p)	%Print to Command Window
% Part III	
% Question A	
[Bin1,Edges1] = histcounts(A{:,5},0:10:100);	%Create Bins of Histogram
Data	
[Bin2,Edges2] = histcounts(A{:,6},0:10:100);	%Create Bins of Histogram
Data	
[BinO,EdgesO] = histcounts(A{:,7},0:10:100);	%Create Bins of
Histogram Data	
Ymax = max([Bin1,Bin2,BinO]);	%Define Maximum of Y Axis
% Question B	
figure(2)	%Initialise Figure
subplot(1,3,1)	%Create Subplot
histogram(A{:,5},Edges1)	%Plot Histogram
grid on	%Activate Grid
xlabel('Class Limits')	%Define X Axis Label
ylabel('Frequency')	%Define Y Axis Label
ylim([0,Ymax])	%Define Y Axis Limits
title('Exam 1 Histogram')	%Define Title Of Plot
subplot(1,3,2)	%Create Subplot
histogram(A{:,6},Edges2)	%Plot Histogram
grid on	%Activate Grid
xlabel('Class Limits')	%Define X Axis Label
ylabel('Frequency')	%Define Y Axis Label
ylim([0,Ymax])	%Define Y Axis Limits
title('Exam 2 Histogram')	%Define Title Of Plot
subplot(1,3,3)	%Create Subplot
histogram(A{:,7},EdgesO)	%Plot Histogram
grid on	%Activate Grid

xlabel('Class Limits')	%Define X Axis Label
ylabel('Frequency')	%Define Y Axis Label
ylim([0,Ymax])	%Define Y Axis Limits
title('O/All Results Histogram')	%Define Title Of Plot
% Question C	
Ex1Red = cumsum(Bin1)/100;	%Normalised Cumulative
Frequency	
Ex1Blue = cumsum(Bin1,'Reverse')/100;	%Inverse Normalised
Cumulative Frequency	
Ex2Red = cumsum(Bin2)/100;	%Normalised Cumulative
Frequency	
Ex2Blue = cumsum(Bin2,'Reverse')/100;	%Inverse Normalised
Cumulative Frequency	
ExORed = cumsum(BinO)/100;	%Normalised Cumulative
Frequency	
ExOBlue = cumsum(BinO,'Reverse')/100;	%Inverse Normalised
Cumulative Frequency	
figure(3)	%Initialise Figure
subplot(1,3,1)	%Create Subplot
plot(Edges1,[Ex1Blue,0],'b.-',Edges1,[0,Ex1Red],'r.-')	%Plot Ogive
grid on	%Activate Grid
xlabel('Class Limits')	%Define X Axis Label
ylabel('Cumulative Relative Frequency')	%Define Y Axis Label
title('Exam 1 Ogives')	%Define Title
subplot(1,3,2)	%Create Subplot
plot(Edges2,[Ex2Blue,0],'b.-',Edges2,[0,Ex2Red],'r.-')	%Plot Ogive
grid on	%Activate Grid
xlabel('Class Limits')	%Define X Axis Label
ylabel('Cumulative Relative Frequency')	%Define Y Axis Label
title('Exam 2 Ogives')	%Define Title
subplot(1,3,3)	%Create Subplot
plot(EdgesO,[ExOBlue,0],'b.-',EdgesO,[0,ExORed],'r.-')	%Plot Ogive
grid on	%Activate Grid
xlabel('Class Limits')	%Define X Axis Label
ylabel('Cumulative Relative Frequency')	%Define Y Axis Label

title('O/All Results Ogives')

%Define Title