

# STUDY NOTES



## FURTHER MATHS UNIT 3

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FURTHER MATHS  
VCE REVISION CLASS NOTES

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These notes have been designed with the student in mind, taking into account that the student will already be bombarded with course reading material, handouts as well as possibly a number and variety of subject notes and materials. As a result, the writing in these notes is kept to a minimum with the intention of providing information that is relevant and to the point. Examples are used when required to illustrate a point being made. In many cases point form summaries are used, as this provides accurate information in a concise and summarised manner, helping to reduce reading and study time without compromising on study quality.

The notes have been prepared for use as part of the **A1 TUITION** Unit 3 VCE Revision Class series. Although the notes are an integral part of the Further Maths revision class, they have been prepared in a way that enables the student to use them on a stand-alone basis.

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These study notes should be used as part of subject and topic revision, ideally after each topic is covered in class, as well as prior to exam and SAC sitting dates.

I sincerely hope that you find these notes useful and relevant, and that they may enable you to get those extra few marks that you need to get into the course of your choice next year.

*Richie Harun*

# UNIVARIATE DATA

## UNIVARIATE DATA

TYPES OF DATA

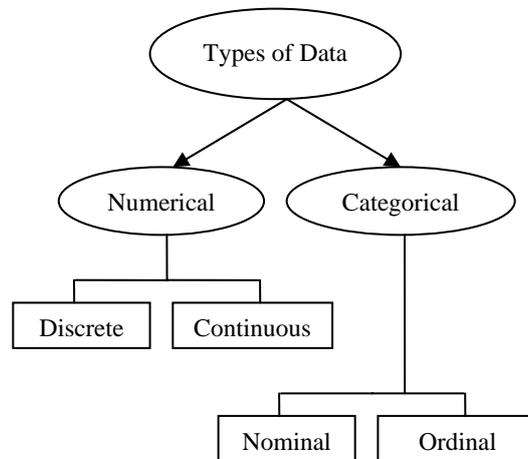
THE MEAN & STANDARD DEVIATION

THE 68-95-99.7% RULE

TI TRICKS

# CORE UNIVARIATE DATA STUDY NOTES

## TYPES OF DATA



### ***Categorical Data:***

The objects are being grouped into categories. For example:

Sex: Male, female.

Hair Color: black, blonde, brown, red etc.

Smoking status: smoker, non-smoker.

### ***Numerical Data:***

The objects are being measured in some quantitative forms. For example:

Height, age, ENTER score, cholesterol level etc.

**Discrete:** When only certain values are possible (i.e. there are gaps in between possible values). For example: number of students.

**Continuous:** When any values within an interval are possible. For example: ENTER score.

## STEM PLOTS

A stem and leaf plot is a way of displaying a data set. Stem and leaf plots are usually used for a small set of observations.



### **Example-1**

The number of people visiting a car dealership every day is as follows:

16, 22, 23, 30, 22, 36, 34, 32, 42, 47, 46, 43, 53, 57, 61

Construct a stem and leaf plot.

First step is to re-arrange the data from smallest to largest:

16, 22, 22, 23, 30, 32, 34, 36, 42, 43, 46, 47, 53, 57, 61

Now, find the lowest & highest number.

# CORE UNIVARIATE DATA STUDY NOTES

Lowest Number: 16  
Highest Number: 61  
So, use stems 1- 6.

Stem	Leaf
1	6
2	2 2 3
3	0 2 4 6
4	2 3 6 7
5	3 7
6	1

**NOTE:** Refer to TI Tricks 1, for some tips on how to use a graphics calculator for data sorting.

## FREQUENCY HISTOGRAMS AND BAR CHARTS

Frequency histograms are a graphical way of displaying data. They are usually used when the number of observations is quite large (more than 50 observations).

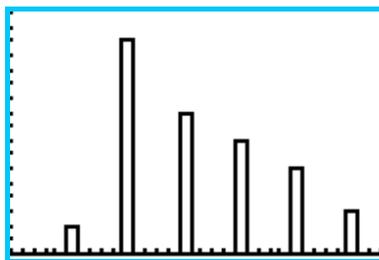


### Example-2

The following table shows the ENTER scores achieved by students from a particular school.

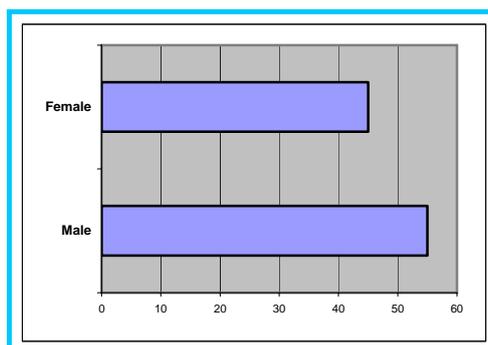
MARK	70	75	80	85	90	95
FREQUENCY	2	15	10	8	6	3

Draw a frequency histogram from the table above.



**NOTE:** Refer to TI Tricks 2, for some tips on how to use a graphics calculator to draw histograms.

Bar charts are similar to histograms, except that unlike histograms, they can show different categories. The data can be shown either vertically or horizontally.



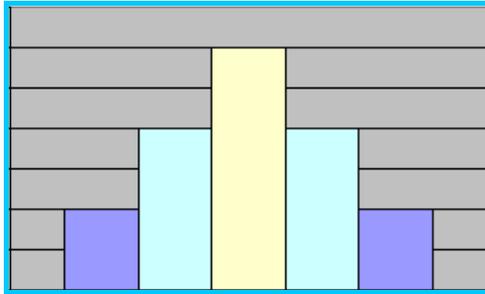
# CORE UNIVARIATE DATA STUDY NOTES

## SKEWNESS OF PLOTS

Skewness describes the shape of the stem plots or histograms.

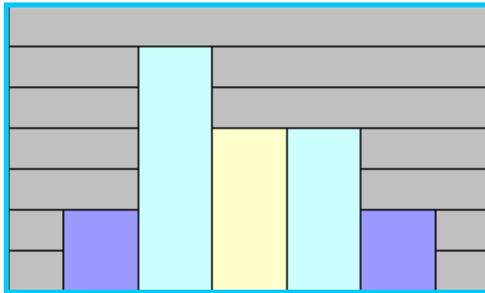
### *Symmetric*

There is a single peak right in the middle and data trails off on both side of the peak roughly following the same shape.



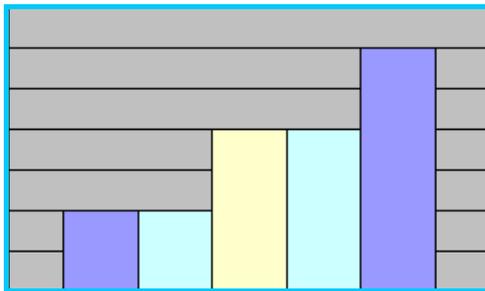
### *Positively Skewed*

The peak for positive skewness is on the left and the data trails off to the right.



### *Negatively Skewed*

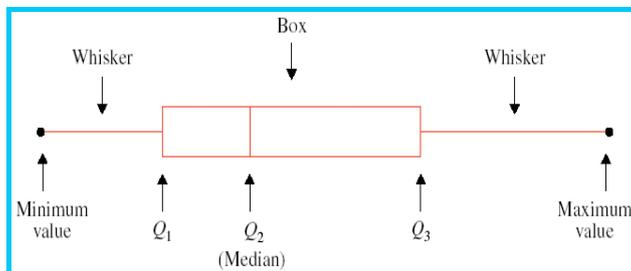
The peak for negative skewness is on the right and the data trails off to the left.



# CORE UNIVARIATE DATA STUDY NOTES

## BOX PLOTS

Box plots show the minimum and maximum values with quartiles that are drawn on a scale. Below is a diagram of a box plot:



Box plots show the following five key features of a data spread:

- ❖ **Minimum:** Is the smallest value in the data set.
- ❖ **Maximum:** Is the largest value in the data set.
- ❖ **Median:** Is the midpoint of the data set. Median is given by the following formula.

$$\left( \frac{n+1}{2} \right) \text{ [where } n \text{ is number of records in the data set]}$$

- ❖ **First Quartile (Q<sub>1</sub>):** Midpoint of the lower half of the data set values.
- ❖ **Third Quartile (Q<sub>3</sub>):** Midpoint of the upper half of the data set values.

- ❖ **IQR:** is the middle 50% of the data set. It is given by:

$$Q_3 - Q_1$$



### Example-3

The data provided below shows the height of students in year 10.

155 158 159 160 162 163 165 168 169 170 174 175 175 178 179 180 181 183 184 188 190 195

Draw a box plot.

In order to draw the box plots we have to find the five features of the dataset.

From “1-Vars Stats” function of the graphics calculator, we can work out the five key features that we need to draw a box plot.

Refer to the “TI-Tricks 3” to see how to derive these values.

# CORE UNIVARIATE DATA STUDY NOTES

```

1-Var Stats
n=22
minX=155
Q1=163
Med=174.5
Q3=181
maxX=195

```

**Hint:** 

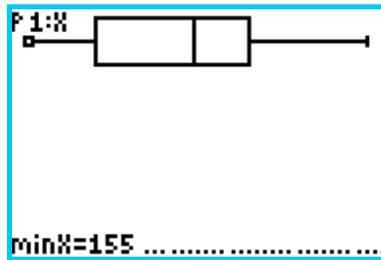
Use the DOWN ARROW key to check the 5 key features.

As the above screenshot illustrates:

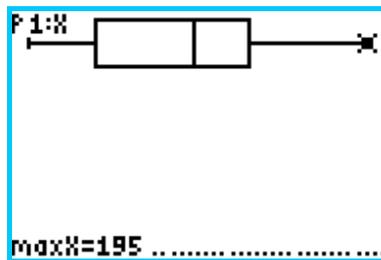
- ◇ Minimum = 155
- ◇  $Q_1 = 163$
- ◇ Median = 174.5
- ◇  $Q_3 = 181$
- ◇ Maximum = 195

Now from this information our box plot can be drawn.

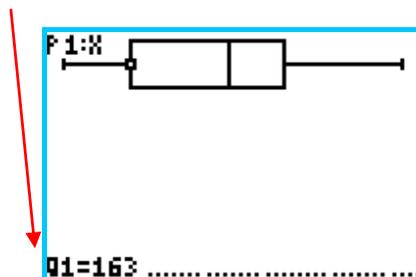
The **min value** is the **left most value** on the **left whisker** of the box plot as show below. This means that it is the lowest value of the data set.



The **max value** is the **right most value** on the **right whisker** of the box plot as show below. This means that it is the highest value of the data set.

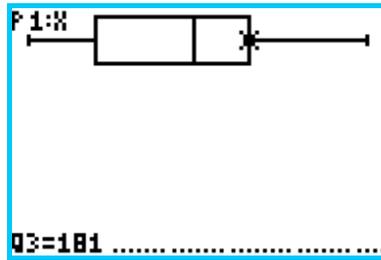


Now draw your box along  $Q_1$  and  $Q_3$ .  **$Q_1$**  starts at 163. So, **start** the box there.

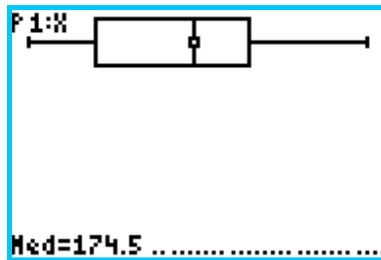


# CORE UNIVARIATE DATA STUDY NOTES

Now draw your **Q3**, which is 181. So, **end** the box there.



The **median** the **midpoint** of the data set, which is in our case, was 174.5 as shown below:



# CORE UNIVARIATE DATA STUDY NOTES

## THE MEAN & STANDARD DEVIATION

### THE MEAN

The mean is the average of a data set. Therefore, mean is given by:

**Mean = Sum of records / number of records.**



#### Example-4

For the data provided below, find the mean:

4 5 6 7 8 9 10.

$$\text{Mean} = \frac{4+5+6+7+8+9+10}{7}$$

$$\therefore \text{Mean} = \frac{49}{7} = 7$$

**NOTE:** Refer to TI Tricks 3, for some tips on how to use graphics calculator for finding mean.

### FINDING THE MEAN USING CLASS INTERVALS AND FREQUENCIES

AGE	FREQUENCY
20-29	2
30-39	8
40-49	6

The table above gives only the frequency; we do not have individual ages. Therefore, we have to use this information to calculate the mean.

AGE	FREQUENCY $f$	MID-POINT OF CLASS INTERVAL	$f \times m$
20-29	2	24.5	49
30-39	8	34.5	276
40-49	6	44.5	267
	$\sum f = 16$		$\sum (f \times m) = 592$

Now the mean is given the follow formula:

$$\text{Mean} = \frac{\sum (f \times m)}{\sum f}$$

$$\therefore \bar{x} = \frac{\sum (f \times m)}{\sum f} = \frac{592}{16} = 37$$

This is another way of calculating the **mean** when **only** the **frequency** is given.

# CORE UNIVARIATE DATA STUDY NOTES

## STANDARD DEVIATION (SD)

Standard deviation is given by the following formula:

$$s = \sqrt{\frac{\sum (x - \bar{x})^2}{n - 1}}$$



### Example-5

For the data given below find the standard deviation:

4 5 6 7 8 9 10.

x	Mean	(x - $\bar{x}$ )	(x - $\bar{x}$ ) <sup>2</sup>
4	7	3	9
5	7	2	4
6	7	1	1
7	7	0	0
8	7	-1	1
9	7	-2	4
10	7	-3	9
			28

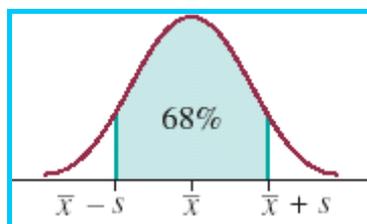
$$s = \sqrt{\frac{\sum (x - \bar{x})^2}{n - 1}} = \sqrt{\frac{28}{6}} = 2.16$$

**NOTE:** Refer to TI Tricks 3, for some tips on how to use graphics calculator for finding S.D.

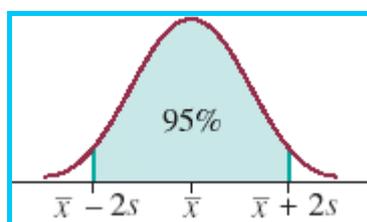
### THE 68-95-99.7% RULE

The 68–95–99.7% rule for a bell-shaped curve states that approximately:

- 68% of data lies within 1 standard deviation either side of the mean:

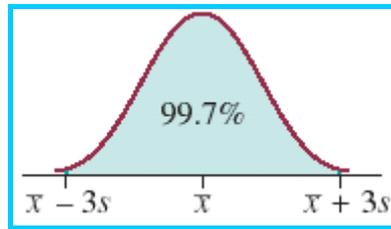


- 95% of data lies within 2 standard deviations either side of the mean:



# CORE UNIVARIATE DATA STUDY NOTES

3. 99.7% of data lies within 3 *standard deviations* either side of the mean:



## Example-6

The mean of sample population is given 10 and the standard deviation is 2. Find the following:

- ❖ 68% of the group lies within what limit;
- ❖ 95% of the group lies within what limit;
- ❖ 99.7% of the group lies within what limit.

%	CALCULATION	DATA GROUP
68%	$10 \pm (2 \times 1)$	8 to 12
95%	$10 \pm (2 \times 2)$	6 to 14
99.7%	$10 \pm (2 \times 3)$	4 to 16

# CORE UNIVARIATE DATA STUDY NOTES

## TI TRICKS

### TI Tricks-1

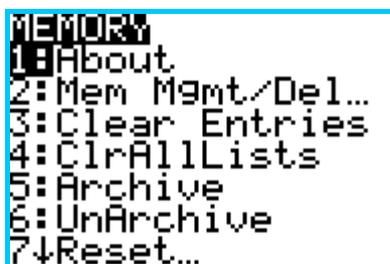
#### ARRANGING DATA FROM LEAST-MOST

When drawing a stem and leaf plot, sometimes the numbers of records given can be as large as 50 records (observations).

Re-arranging manually could involve a fair bit of work. Therefore, use your graphics calculator to make this easier.

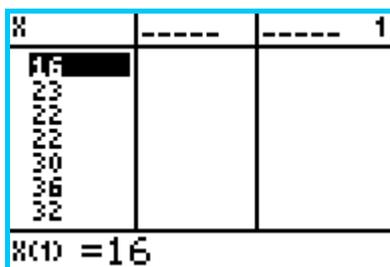
Follow these steps:

- ❖ Clear All Lists first (so all previous tables is deleted).
- ❖ Press “2<sup>nd</sup>” and “+”. You will see the following options:



Screen – 1

- ❖ Scroll down and choose the 4<sup>th</sup> option and clear all lists.
- ❖ Then press “STAT” and from the menu that appears choose “EDIT” and you will see the following window:

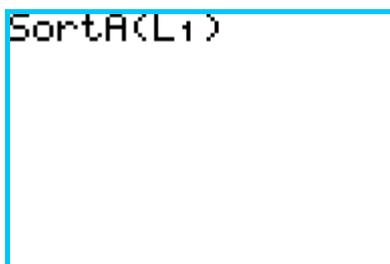


X	-----	-----	1
16			
23			
22			
22			
30			
36			
32			

X(1) = 16

Screen – 2

- ❖ Type all your data in there so that you can sort it much quicker.
- ❖ After typing all the data in, get out of “EDIT”. And again press “STAT” and choose “SortA” (means sorting in ascending order).
- ❖ Now choose L<sub>1</sub> or L<sub>x</sub> depending on the name of your lists (see x in screen 2)



Screen – 3

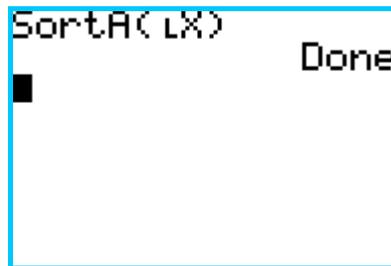
# CORE UNIVARIATE DATA STUDY NOTES



```
SortA(LX)█
```

Screen – 4

Then press “ENTER”.



```
SortA(LX) Done  
█
```

Screen – 5

Now go back to the “STAT” & choose “EDIT” and you will see that the list is sorted in ascending order.



X	-----	----- 1
17		
22		
22		
23		
30		
32		
34		
X(1) = 16		

Screen – 6

Using this simple TI TRICK will make it much easier for you to draw your **Stem Plots** or **Box Plots** where the data needs to be rearranged from least to most.

# CORE UNIVARIATE DATA STUDY NOTES

## TI Tricks-2

### DRAWING HISTOGRAMS

Use the following steps to draw histograms.

Go to “STAT” & “EDIT” and enter all you data in the following manner (Screen 7). So both your data set has been entered into the list.

X	L2	2
70	2	
75	15	
80	10	
85	8	
90	6	
95	3	

L2(1)=2

Screen – 7

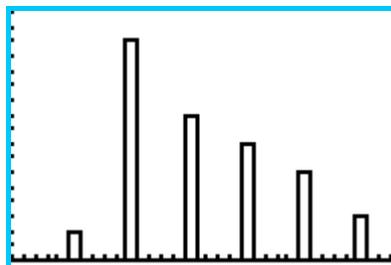
Then press “2<sup>nd</sup>” and “Y=” to go “STAT PLOT”. It will look something like Screen-8.

Plot1	Plot2	Plot3
On	Off	Off
Type:		
Xlist: X		
Freq: L2		

Screen – 8

Do the following under screen-8 options.

- ❏ Turn the plot ON.
- ❏ TYPE: select histogram.
- ❏ And then choose your X-list and Freq (Frequency). In this case the X-list and Freq is X and L2 respectively (screen-7). Make sure you check your “EDIT” screen for your settings and apply changes accordingly.
- ❏ Then press “GRAPH” button and the graph will be drawn as following.



Screen – 9



# CORE UNIVARIATE DATA STUDY NOTES

Then press “ENTER” and the result will be displayed:

```
1-Var Stats
x̄=7
Σx=49
Σx²=371
Sx=2.160246899
σx=2
↓n=7
```

Screen – 13

Now the mean is  $\bar{x} = 7$   
Standard Deviation (SD) is  $S_x = 2.16$ .

Then PRESS the DOWN ARROW key on your calculator to scroll down to the following screen.

```
1-Var Stats
↑n=7
minX=4
Q1=5
Med=7
Q3=9
maxX=10
█
```

Screen – 14

This will display the five key features that are required to draw a box plot.

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# **BIVARIATE DATA**

## **BIVARIATE DATA**

**TYPES OF VARIABLES**

**BACK-TO-BACK STEP PLOT**

**PARALLEL BOX PLOTS**

**SCATTER PLOTS**

**Q – CORRELATION COEFFICIENT**

**PEARSON'S PRODUCT MOMENT CORRELATION COEFFICIENT**

**COEFFICIENT OF DETERMINATION**

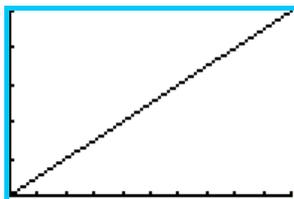
**TI TRICKS**

**CORE**  
**BIVARIATE DATA**  
**STUDY NOTES**

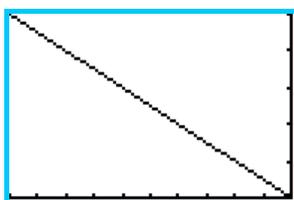
## TYPE OF VARIABLES

In a relationship involving two variables, one variable depends on the other variable. Such variables are called “Dependent Variables”.

As x increases, y increases:



As x decreases, y decreases:



X-axis is ALWAYS the “Independent” variable.

Y-axis is ALWAYS the “Dependent” variable.

Therefore, y-values ALWAYS depend on x-values.

The important part is to recognise which is dependent or independent.



### Example-1

The number of years of experience of a manager and his salary.

The more experienced the manager is, the more likely it is that his salary will be higher. Therefore, the salary is **dependent** on his experience.

Average time of study and corresponding test score.

The more a student studies for a test, it's more likely that he/she will do better. Therefore, test score is **dependent** on how much he/she studies.

The number of children in a family and the size of their house.

The bigger the family, the bigger the house size is required. Therefore, the size of the house is **dependent** on the number of children in the family.

# CORE BIVARIATE DATA STUDY NOTES

## BACK TO BACK STEM PLOTS

A back-to-back stem plot is used to display bivariate data. The back-to-back stem plot allows us to compare two distributions rather than one.



### Example-2

The ENTER scores for a certain school between boys and girls is given below:

<b>BOYS</b>	<b>55</b>	<b>63</b>	<b>78</b>	<b>84</b>	<b>95</b>	<b>97</b>
<b>GIRLS</b>	<b>62</b>	<b>68</b>	<b>75</b>	<b>79</b>	<b>83</b>	<b>89</b>

Draw a back-to-back stem plot.

Leaf Boys	Stem	Leaf Girls
5	5	
3	6	2, 8
8	7	5, 9
4	8	3, 9
5, 7	9	

## PARALLEL BOX PLOTS

A parallel box plot is another way of comparing a number of distributions at once. The main aspect is to draw both box plots on the **same axis**. That way, a visual comparison can be made between two sets of distributions.



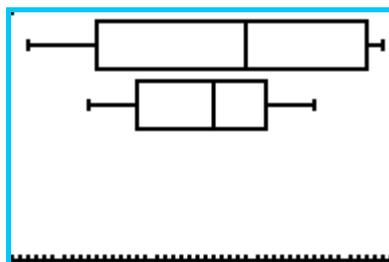
### Example-3

The ENTER scores for a certain school between boys and girls is given below:

<b>BOYS</b>	<b>55</b>	<b>63</b>	<b>78</b>	<b>84</b>	<b>95</b>	<b>97</b>
<b>GIRLS</b>	<b>62</b>	<b>68</b>	<b>75</b>	<b>79</b>	<b>83</b>	<b>89</b>

Draw a parallel box plot.

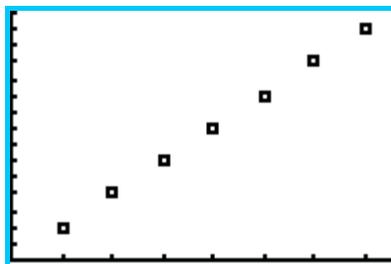
The parallel box plot would look something like this:



# CORE BIVARIATE DATA STUDY NOTES

## SCATTER PLOT

Scatter plots are similar to line graphs in that they use horizontal and vertical axes to plot data points. However, they have a very specific purpose. Scatter plots show how much one variable is affected by another. The relationship between two variables is called their **correlation**.



The graph above shows **Perfect Positive Correlation** between the two variables.



### Example-4

The table below shows the number of fatalities related to the amount of alcohol in the bloodstream when driving. Draw a scatter plot to display this relationship.

<b>BLOOD/ALCOHOL READING</b>	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
<b>NO. OF FATALITIES</b>	3	5	6	5	8	10	9	11

**Note: This set of data is NOT REAL. Do not follow this example in a real life situation.**

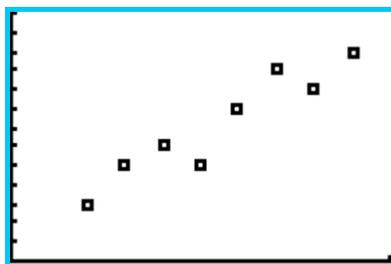
First of all, decide about the type of the variable.

The number of fatalities depends on the amount of alcohol in the blood. Therefore:

**Dependent Variable (Y-axis):** No. of fatalities.

**Independent Variable (X-axis):** Amount of alcohol in the blood.

Now we can plot the points on the axis and obtain the following graph:



From the graph it can be seen that there is a *positive* linear relationship between the two variables. Characteristics of a scatter plot are as following:

**Direction:** positive (*sloping up*) or negative (*sloping down*).

**Form:** linear (*straight line*) or non-linear (*non-straight line*).

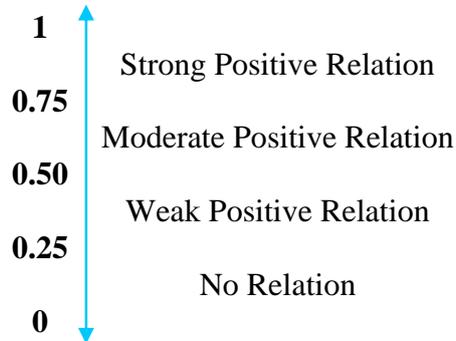
**Strength:** strong, moderate or weak.

Refer to the diagram in q-correlation section on how to measure the strength.

# CORE BIVARIATE DATA STUDY NOTES

## *q* – CORRELATION COEFFICIENT

The *q* – correlation coefficient is a measure of the strength of the relationship between two variables. The diagram below shows the strength associated with *q*-value:



Use the following steps when calculating *q* – correlation coefficient.

1. Draw the scatter plot.
2. Find the median *y*-values.
3. Find the median *x*-values.
4. Divide the scatter plot into 4 sections (a, b, c & d). Clockwise from the top-right section name the sections.
5. Calculate the *q* – correlation coefficient. The formula is as follows:

$$q = \frac{(a + c) - (b + d)}{a + b + c + d}$$

Where a, b, c & d are 4 sections on the scatter plot.



### Example-5

The table below shows the number of fatalities related to the amount of alcohol in the bloodstream when driving. Calculate the *q*-correlation coefficient.

BLOOD/ALCOHOL READING	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
NO. OF FATALITIES	3	5	6	5	8	10	9	11

The median *x*-value is:

$$\frac{n + 1}{2} = \frac{8 + 1}{2} = 4.5$$

Which is between the 4<sup>th</sup> and 5<sup>th</sup> *x*-values.

The median *y*-value is:

$$\frac{n + 1}{2} = \frac{8 + 1}{2} = 4.5$$

Which is between the 4<sup>th</sup> and 5<sup>th</sup> *y*-values.

Now divide the scatter plot according the median *x* & *y*-values as shown in the diagram on the following page.

# CORE BIVARIATE DATA STUDY NOTES



**NOTE:** When drawing the median x-value, MAKE SURE there is the same NUMBER of points of EACH SIDE.

**NOTE:** When drawing the median y-value, MAKE SURE there is the same NUMBER of points of EACH SIDE.

Now just count the number of points in each sections and those are the values of a, b, c & d.

$$a = 4$$

$$b = 0$$

$$c = 4$$

$$d = 0$$

$$q = \frac{(4 + 4) - (0 + 0)}{4 + 0 + 4 + 0} = \frac{8}{8} = 1$$

This indicates a **strong positive** relationship between the “amount of alcohol in the blood” & “number of fatalities”.

## PEARSON’S PRODUCT MOMENT CORRELATION COEFFICIENT

Pearson’s product moment correlation coefficient is another measure of correlation coefficient but more **accurate** than q-correlation coefficient.

The symbol for the correlation coefficient is **r**. The estimates of **r** can be obtained from the scatter plot.

**TIP:** Copy the Pearson’s product moment correlation diagrams from your textbook onto your cheat sheet.

# CORE BIVARIATE DATA STUDY NOTES

## COEFFICIENT OF DETERMINATION

The coefficient of determination is calculated by  $r^2$ , which means square the Pearson's product moment correlation coefficient value.

The coefficient of determination tells us the % of variation in between the variables.



### Example-6

If ( $r=0.9$ ) was the Pearson's correlation coefficient in the previous example, then calculate the coefficient of determination.

$$\text{Coefficient of Determination} = r^2 = (0.9)^2 = 0.81$$

From that we can conclude that 81% of variation in the number of "fatalities" can be explained by the variation in the "amount of alcohol in the bloodstream" of the driver.

**NOTE:** The line explaining the coefficient of determination above is always the same. Therefore, copy the following line down onto your cheat sheet.

*"We can conclude that ...% of variation in the 'Dependent Variable / y-axis' can be explained by the variation in the 'Independent Variable / x - axis'."*

# CORE BIVARIATE DATA STUDY NOTES

## TI TRICKS

### TI Tricks-1

#### DRAWING PARALLEL BOX PLOTS

- ✦ Insert the different sets of data into their own corresponding LIST, as shown below:

L1	L2	L3
55	62	
63	68	
78	75	
84	79	
95	83	
97	89	
---	---	
L3(1)=		

- ✦ Go to “STAT PLOT” and select “PLOT1”.

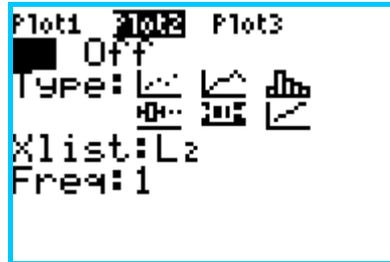
STAT PLOTS	
1: Plot1...On	
$\square$ L1	1
2: Plot2...On	
$\square$ L2	1
3: Plot3...Off	
$\square$ L1	L2
4: PlotsOff	

- ✦ Make the following changes on the screen.
1. Turn “PLOT1” ON.
  2. Choose the type (Boxplot).
  3. Set “Xlist” to the list no. 1 (where the first set of data is).
  4. Set “Freq” to 1 (so it will show each unit).

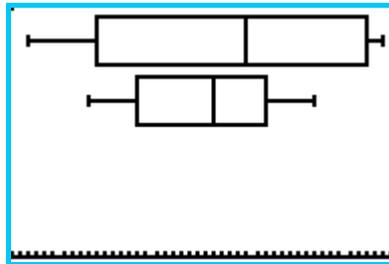
Plot1	Plot2	Plot3
On	Off	
Type:	$\square$	$\square$
	$\square$	$\square$
Xlist:	L1	
Freq:	1	

# CORE BIVARIATE DATA STUDY NOTES

- ✦ Make the following changes on the screen.
1. Turn "PLOT2" ON.
  2. Choose the type (Boxplot).
  3. Set "Xlist" to the list no. 2 (where the first set of data is).
  4. Set "Freq" to 1 (so it will show each unit).



Then "Graph" the plots, which will look this:



# CORE BIVARIATE DATA STUDY NOTES

## TI Tricks-2

### CORRELATION COEFFICIENT & COEFFICIENT OF DETERMINATION

- After drawing the scatter plot on the calculator go to “STAT” → “CALC” → “LinReg(ax+b)” as shown in the diagram below:

```
EDIT [2ND] [MODE] TESTS
1:1-Var Stats
2:2-Var Stats
3:Med-Med
4:LinReg(ax+b)
5:QuadReg
6:CubicReg
7↓QuartReg
```

- The following line will appear, where you type in “L1, L2” (this is based on the LIST where you put your information).
- Then press “ENTER”.

```
LinReg(ax+b) L1,
L2
```

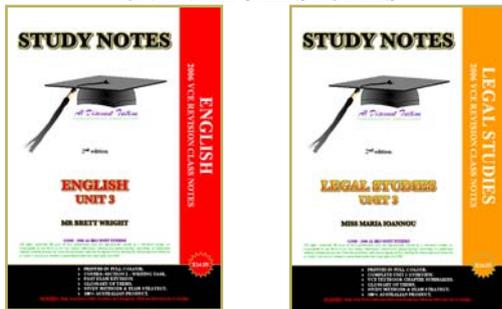
A screen will appear showing the value of following:

- Equation of the linear line ( $y = ax + b$ ).
- Pearson product moment correlation coefficient ( $r$ ).
- Coefficient of Determination ( $r^2$ ).

```
LinReg
y=ax+b
a=10.83333333
b=1.166666667
r^2=.8982536067
r=.947762421
```

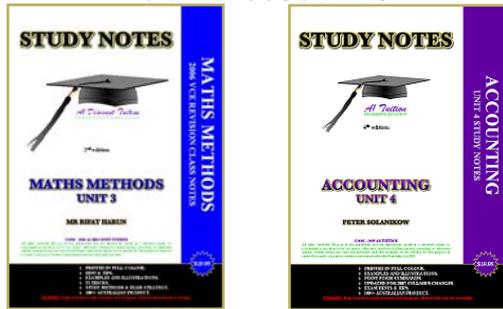
## STUDY NOTES

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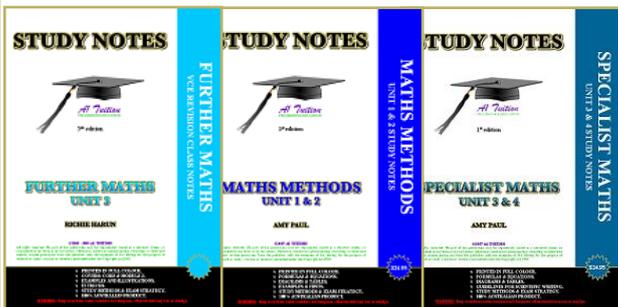
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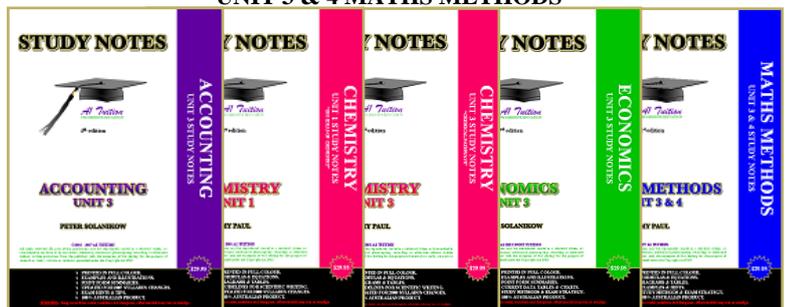
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