

Level 5 – Continuous Improvement with Industry 4.0

Analyse 1 – OEE recap and different types of data



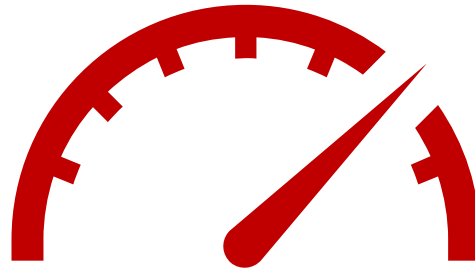


Level 5 – Continuous Improvement with Industry 4.0

Measure 4 – Overall Equipment Effectiveness (OEE)



Availability



Performance



Quality

**= Overall Equipment
Effectiveness (OEE)**



Overall Equipment Effectiveness (OEE)

Focuses on the 'six big losses' experienced within manufacturing environments:-

Availability

- Equipment failure
- Set up and changeovers

Performance

- Machinery idling
- Reduced speed

Quality

- Yield, re-work and scrap
- Start up losses

Listen to your process

- What are your thoughts on some data you've just seen from your production area for last week?

OEE Factor	16-Nov-20	23-Nov-20
OEE	85.10%	85.70%
Availability	90.00%	95.00%
Performance	95.00%	95.00%
Quality	99.50%	95.00%



OEE Example

Item	Data
Shift Length	12 hours (720 minutes)
Breaks	45 minutes
Downtime	59 minutes
Ideal cycle time	1 minute
Total Count	601 widgets
Reject Count	25 widgets

Planned Production Time = Shift Length – Breaks

Run Time = Planned Production Time - Downtime

Good Count = Total Count – Reject Count

Availability = Run Time / Planned Production Time

Performance = (Total Count / Run Time) / Ideal Run Rate

Quality = Good Count / Total Count

OEE = Availability * Performance * Quality



Item	Data
Shift Length	12 hours (720 minutes)
Breaks	45 minutes
Downtime	59 minutes
Ideal cycle time	1 minute
Total Count	601 widgets
Reject Count	25 widgets

Planned Production Time = Shift Length – Breaks = 720mins - 45mins **675mins**

Run Time = Planned Production Time - Down Time = 675mins – 59mins = **616mins**

Good Count = Total Count – Reject Count = 601 – 25 = **576**

Availability = Run Time / Planned Production Time = 616mins / 675mins = **0.9125 (91.25%)**

Performance = (Total Count / Run Time) / Ideal Run Rate = (601/ 616 1 unit/min) = **0.9756 (97.56%)**

Quality = Good Count / Total Count = 576 / 601 = **0.9584 (95.84%)**

OEE = Availability * Performance * Quality = 0.9125 * 0.9756 * 0.9584 = **0.8532 (85.32%)**



Overall Equipment Effectiveness (OEE)

Some Caution!

OEE gives no weighting between performance and quality - in many business, quality is paramount to the added cost of re-work, scrap, loss of yield etc.

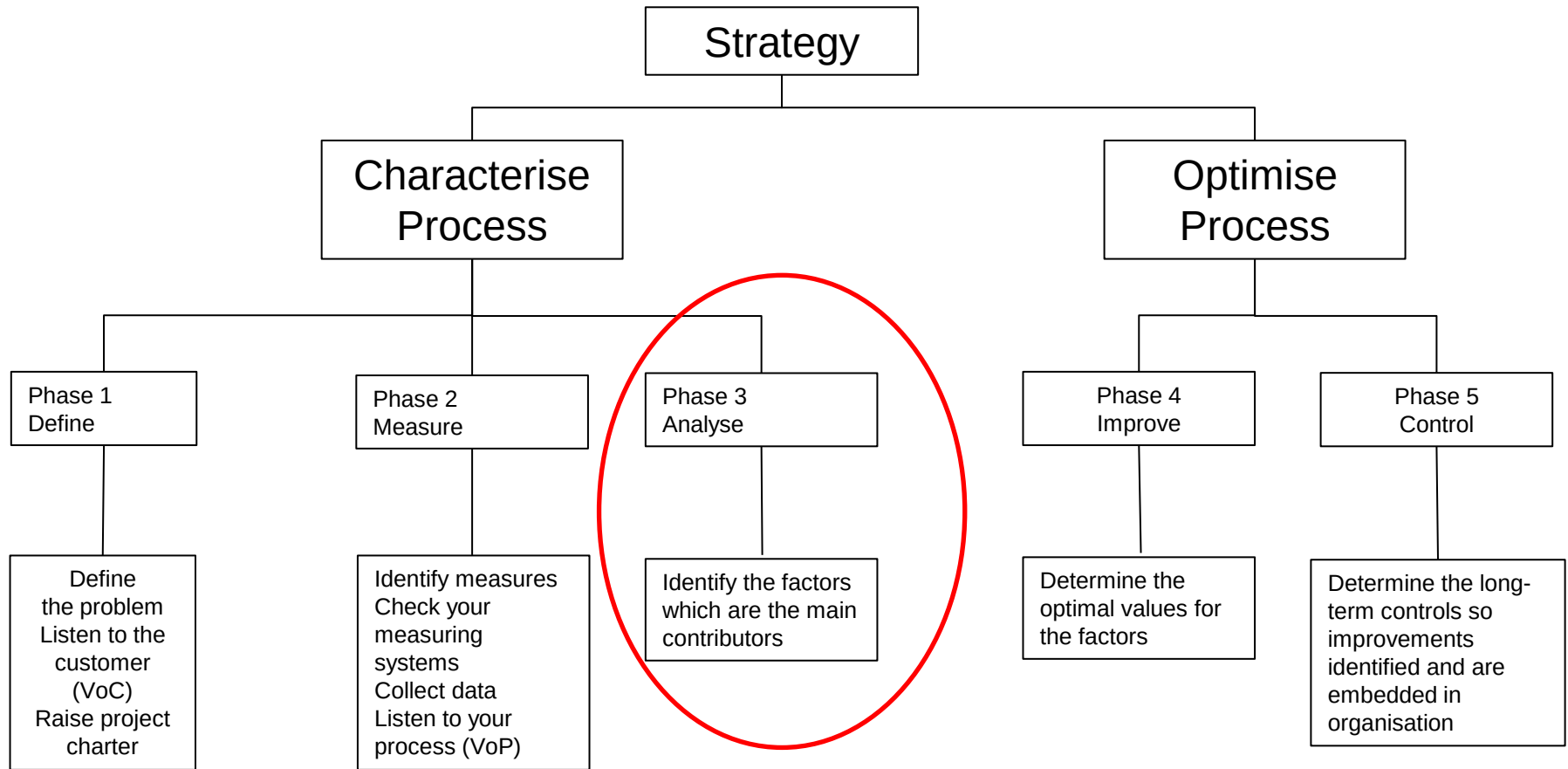
OEE takes no account for what actually is made on the machine – as long as it is running and making conforming product all is good – OEE should always be read in conjunction with schedule adherence

You can improve OEE in good and bad ways – good reducing changeover times – bad – doing less changeovers



Level 5 – Continuous Improvement with Industry 4.0

Analyse 1 – Data Distributions





Analyse – the tools

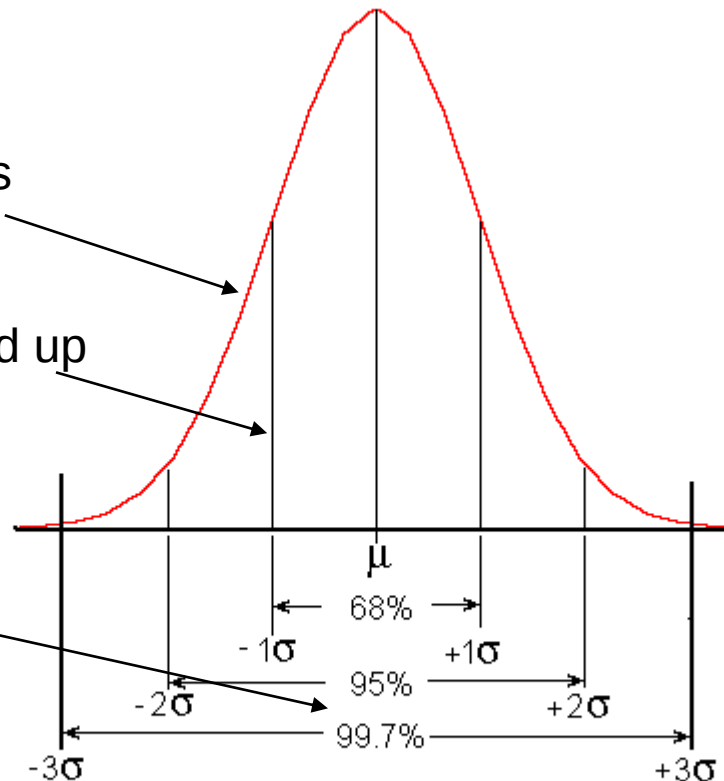
- No data or experience – all we can offer is an opinion
- No data – we use our experience to get through
- Some data - data collected we just look at the numbers
- Grouped data - basic charts and diagrams
- Descriptive statistics - mean, median, mode, Std Dev etc
- Characterising statistics - Cp, Cpk,
- Control statistics - SPC charts (Mr Shewhart!)
- Inferential statistics - normality, regression, DOE etc

Analyse - “Normal data” bell shaped curve

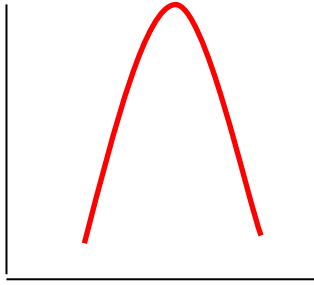
Add up about 30 of most things
and you start to be “normal”

Normal distributions are divided up
into 3 standard deviations on
each side of the mean

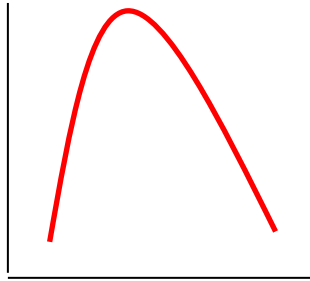
Once you have that, you
know a lot about
what is going on



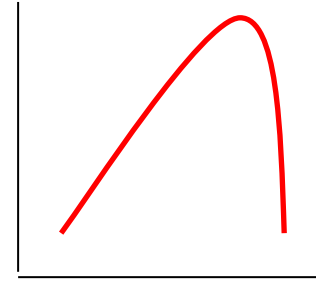
Analyse – distribution shapes



Normal
Distribution



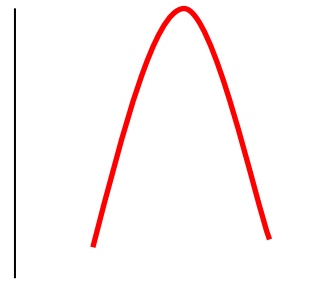
Skewed to
the right



Skewed to
the left

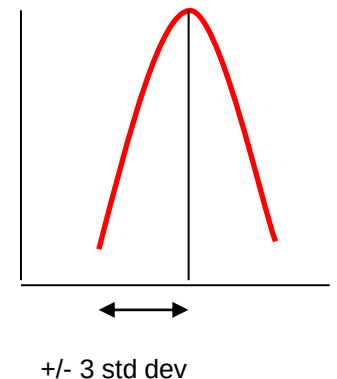
Not all continuous random variables are normally distributed

We need to evaluate how near the set of data is to the normal distribution



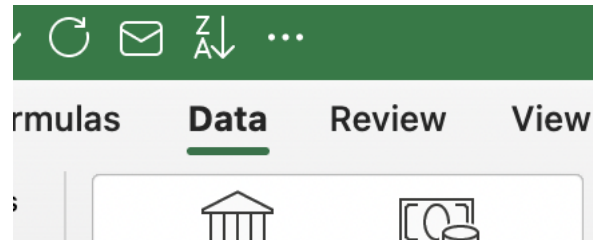
How can we tell?

- Construct a histogram and see if the data has a normal distribution
- Do the mean, median and mode have similar values?
- Is the range approximately 6 standard deviations (± 3 from mean)
- Evaluate mathematically (Excel, Minitab)

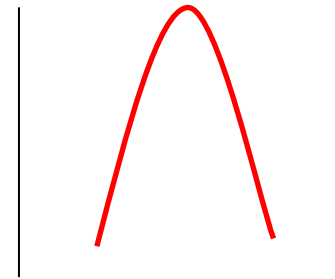
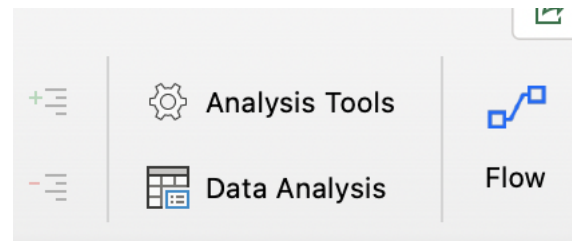


Analyse – Testing for Normality in Excel

- Open new excel spreadsheet and key in the following numbers into a column and click on 'Data' tab

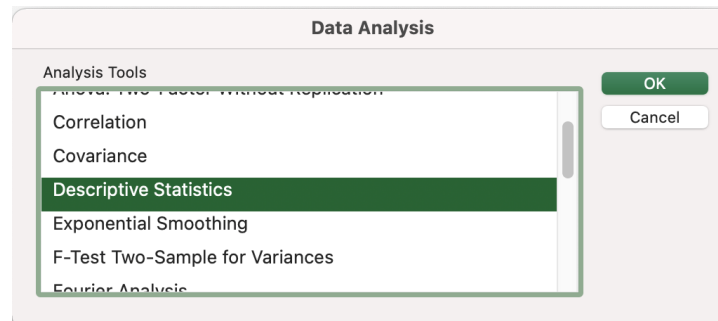


- Click on the 'Data Analysis' icon

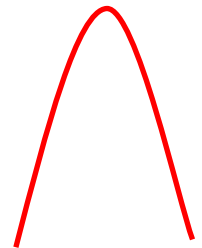
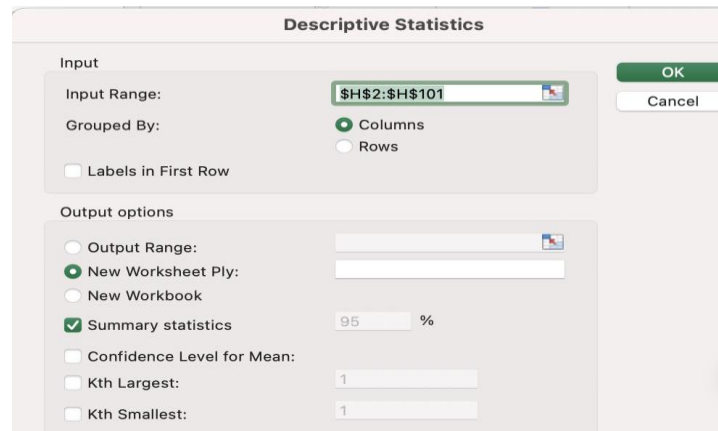


Analyse – Testing for Normality in Excel

- Scroll down and highlight 'Descriptive Statistics' from menu and click 'OK'

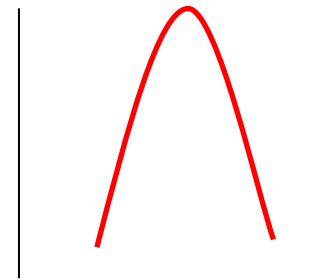


- Click on input range and paint column of numbers, highlight summary statistics and click 'OK'



Analyse – Testing for Normality in Excel

73	Master Final Round 2021		
70			
72			
70	Mean		71.28
73	Standard		
66	Error	0.38952963	
74	Median		72
74	Mode		70
69	Standard		
72	Deviation	1.94764815	
70	Sample		
71	Variance	3.79333333	
74	Kurtosis		0.8140209
72	Skewness		-0.760273
72			
71	Range		8
70	Minimum		66
68	Maximum		74
70	Sum		1782
71	Count		25
70			
73			
72			
72			
73			



Analyse – Testing for Normality in Excel

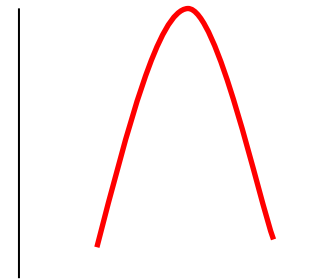
73
70
72
70
73
66
74
74
69
72
70
71
74
72
72
72
71
70
68
70
71
70
73
72
72
73

Master Final Round 2021

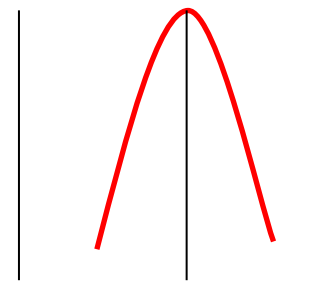
Mean	71.28
Standard Error	0.38952963
Median	72
Mode	70
Standard Deviation	1.94764815
Sample Variance	3.79333333
Kurtosis	0.8140209
Skewness	-0.760273
Range	8
Minimum	66
Maximum	74
Sum	1782
Count	25

The amount in the tails of distribution

Measure of symmetry

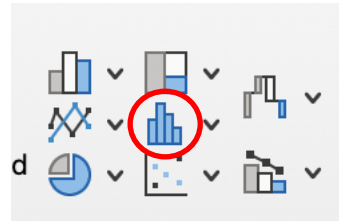


- Kurtosis used to be considered the amount of 'peakness' within a distribution but is now considered to be the amount of the distribution within the tails
- 0 or close to – assumed to be normal
- Less than 0 – distribution has light tails
- Greater than 0 – distribution has heavier tails
- Skewness is a measure of the distributions symmetry
- 0 = normal
- Between -0.5 and 0.5 - fairly symmetrical
- Between -1.0 and 1.0 - moderately skewed
- Less than -1 and greater than 1 - highly skewed

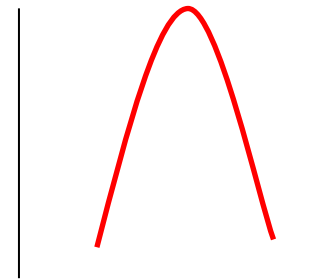


Analyse – Testing for Normality in Excel

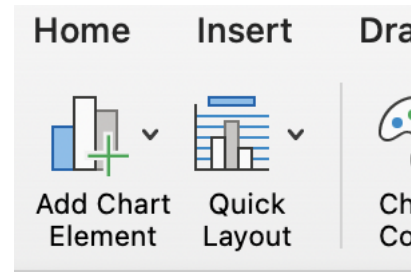
- Paint in numbers choose 'Insert' tab click on histogram icon



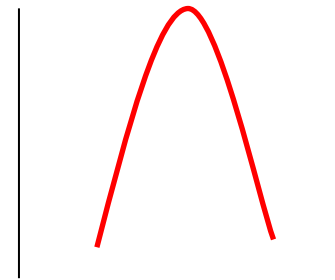
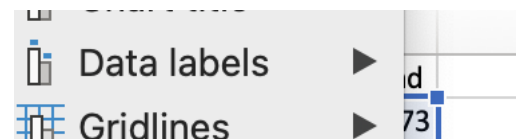
- Choose 'Box and Whisker'



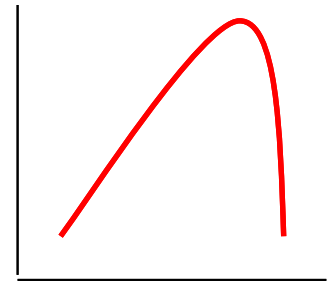
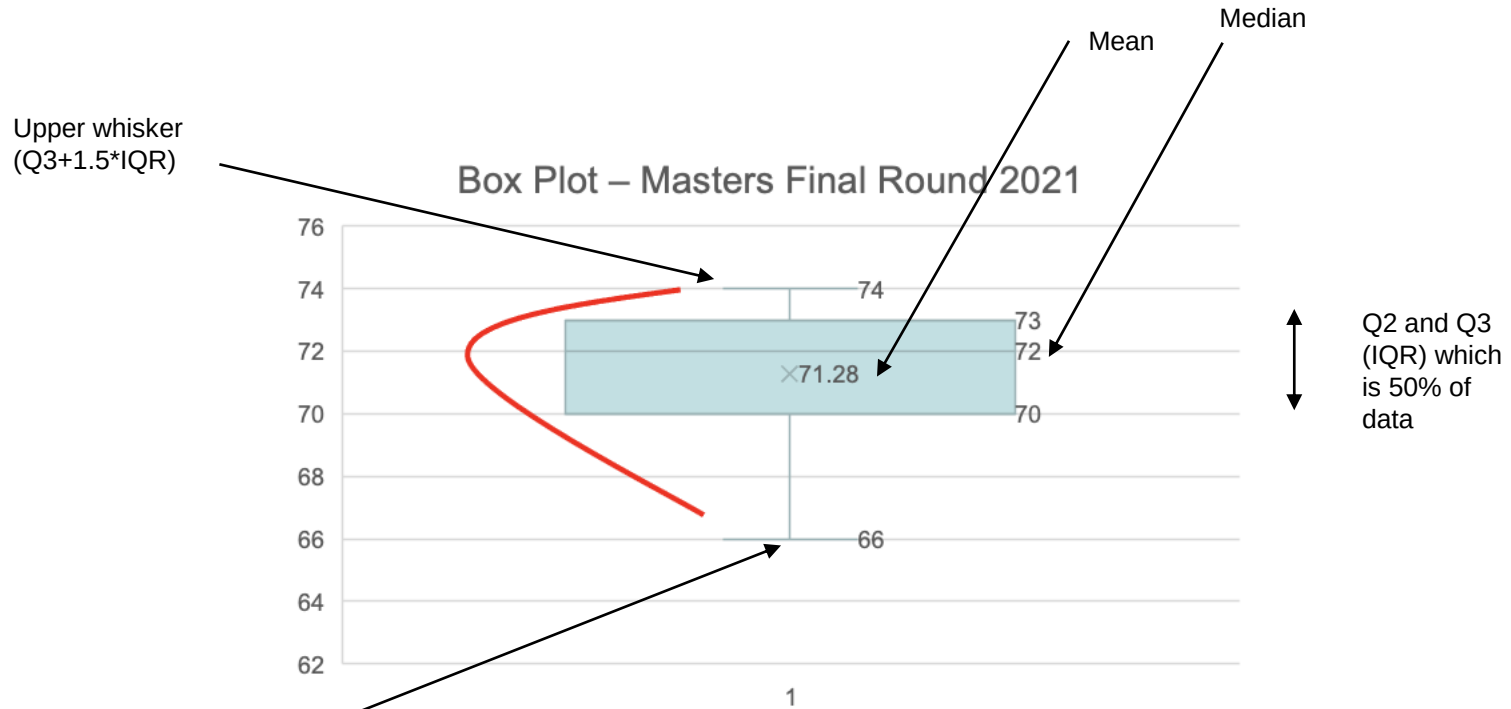
- Choose 'add chart element'



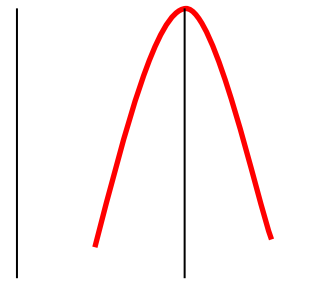
- Choose 'Data Labels' to display values on chart



Analyse – Testing for Normality in Excel



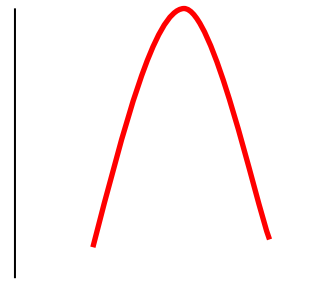
- Those people lucky enough to have Minitab software can undertake the following:-
- Populate the spreadsheet in column
- Choose test for normality 'Anderson-Darling'
- Click 'OK' this will generate a graph and show the distribution
- If P value greater than 0.05, you can consider to have a normal distribution!



Analyse – Testing for Normality in Excel

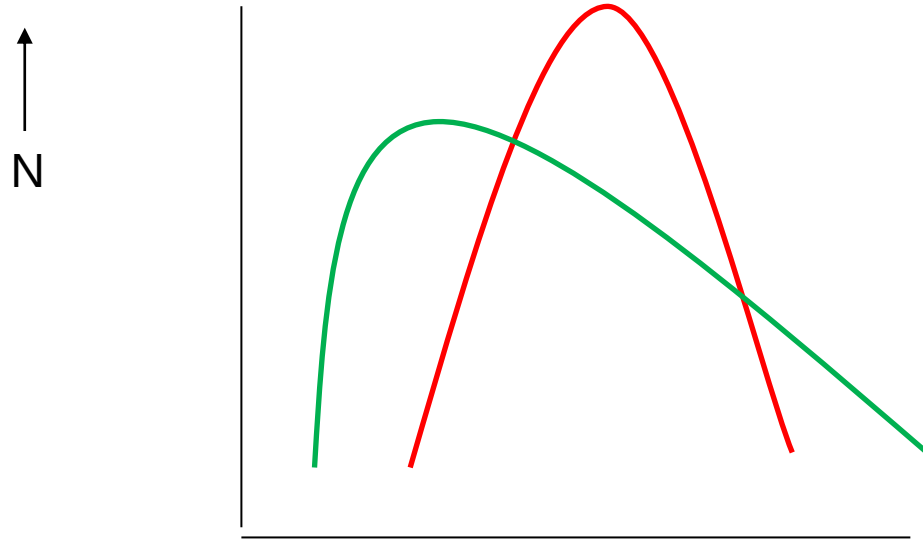


Hideki Matsuyama winner by 1 shot, -10



If the population is not normal, we can apply the 'Central Limit Theorem'

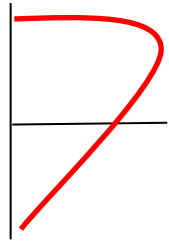
We take the sample means from the population and the distribution of these will move towards the normal distribution as long as the sample size is big enough



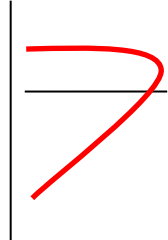
As the sample size increases the means of the data becomes normal



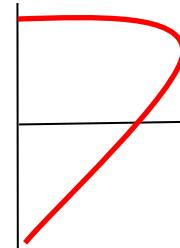
Sample 1 –
short term



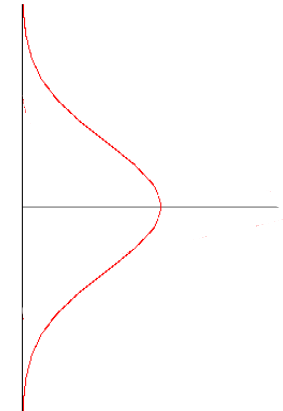
Sample 2 –
short term



Sample 3 –
short term



Population
– long term



Analyse – Central Limit Theorem - example

I rolled 5 dice and noted their individual numbers and worked out the average

Then rolled them a further 99 times

Noted the individual rolls and worked out all the averages

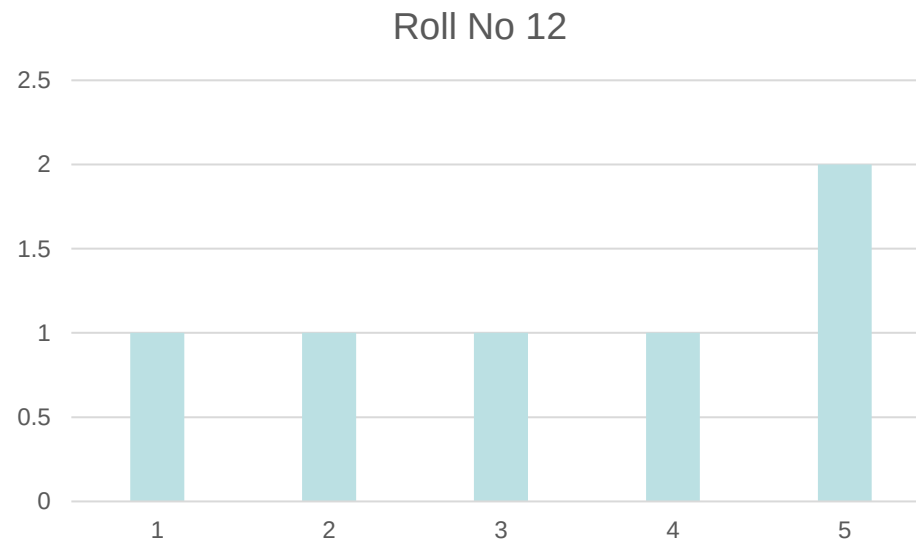
Entered them into a spreadsheet and generated a histogram

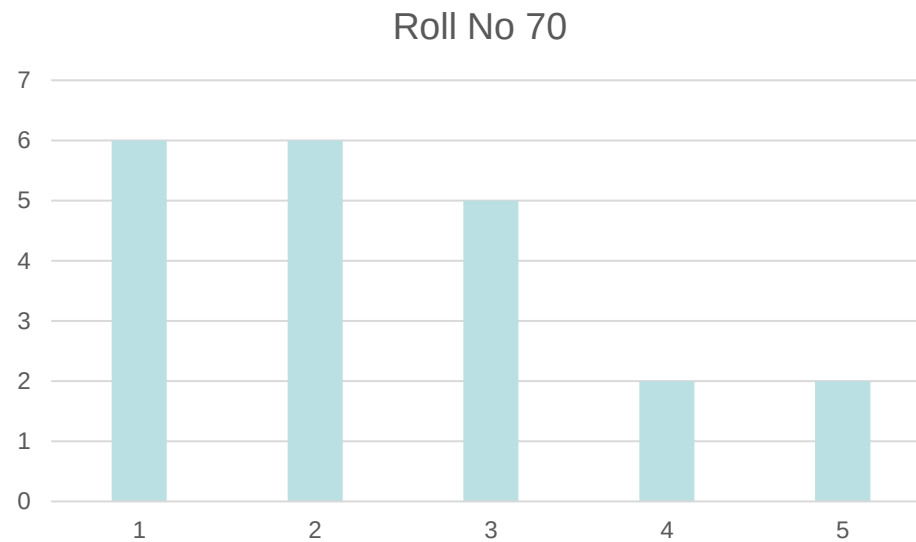


Analyse – Central Limit Theorum - example

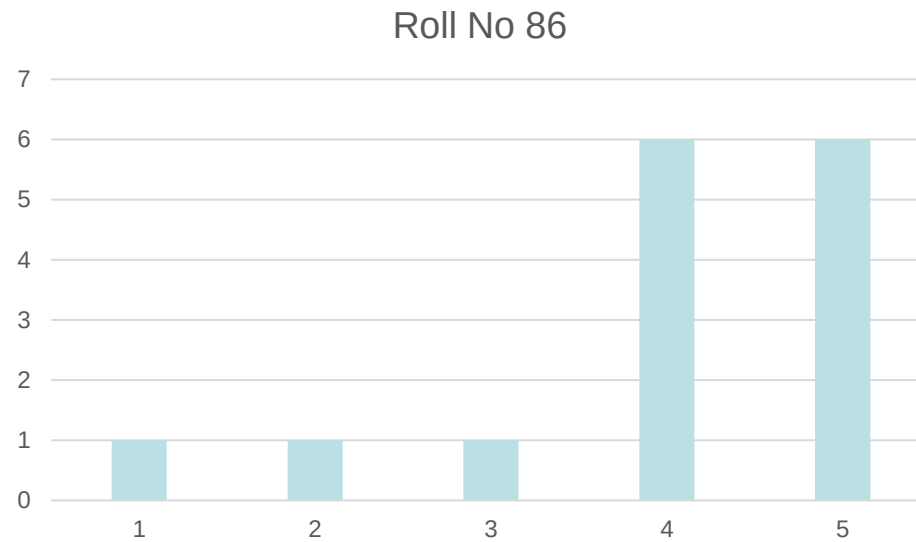
	dice 1	dice 2	dice 3	dice 4	dice 5	mean	
roll	1	3	4	5	1	4	3.4
roll	2	3	1	1	4	5	2.8
roll	3	3	1	3	2	2	2.2
roll	4	1	3	2	1	1	1.6
roll	5	4	5	6	4	2	4.2
roll	6	3	6	2	5	2	3.6
roll	7	6	2	3	5	4	4
roll	8	4	3	6	4	4	4.2
roll	9	3	3	6	6	1	3.8
roll	10	6	3	4	3	6	4.4
roll	11	2	5	3	6	3	3.8
roll	12	3	6	1	2	4	3.2
roll	13	6	4	4	6	6	5.2
roll	14	4	6	6	2	5	4.6
roll	15	1	3	6	2	6	3.6
roll	16	5	4	2	3	4	3.6
roll	17	4	5	4	5	3	4.2
roll	18	5	1	4	1	4	3
roll	19	5	6	1	4	2	3.6
roll	20	4	4	3	5	6	4.4
roll	21	4	1	2	6	4	3.4
roll	22	1	1	5	4	2	2.6
roll	23	3	6	5	4	6	4.8
roll	24	3	2	1	3	6	3
roll	25	1	5	3	2	2	2.6
roll	26	3	5	4	5	4	4.2
roll	27	5	4	6	2	6	4.6
roll	28	3	6	1	3	6	3.8
roll	29	1	5	3	5	5	3.8
roll	30	3	4	4	4	4	3.8



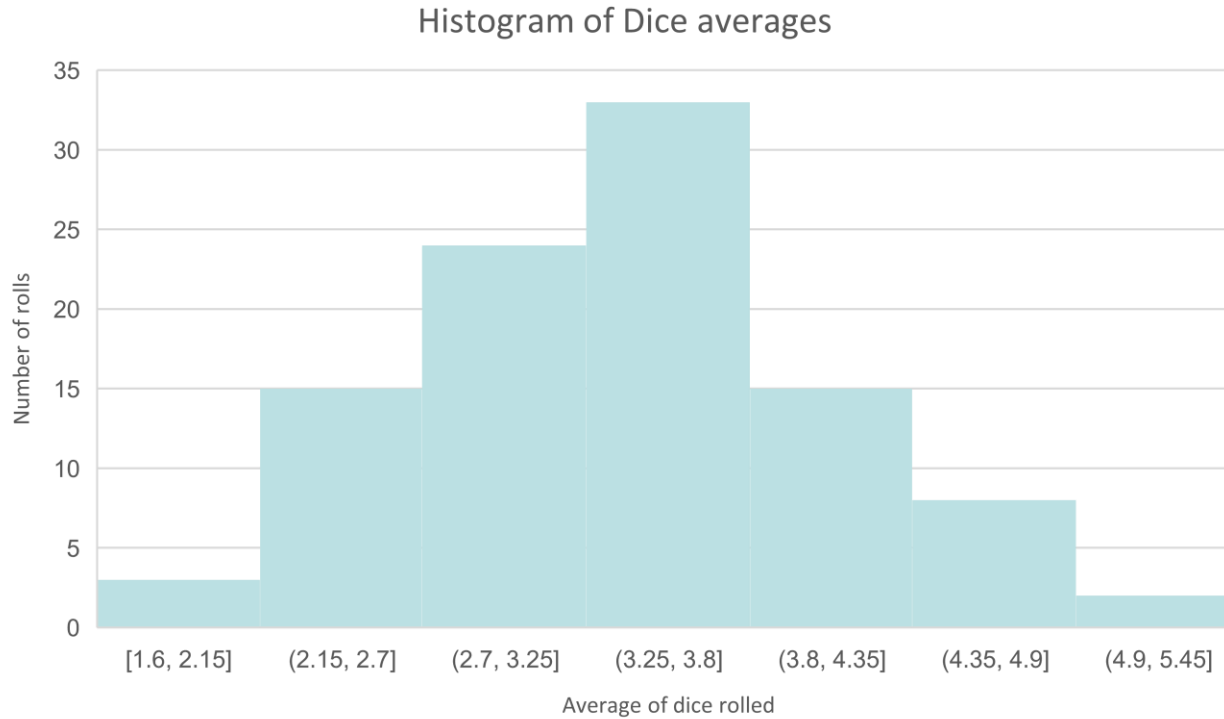


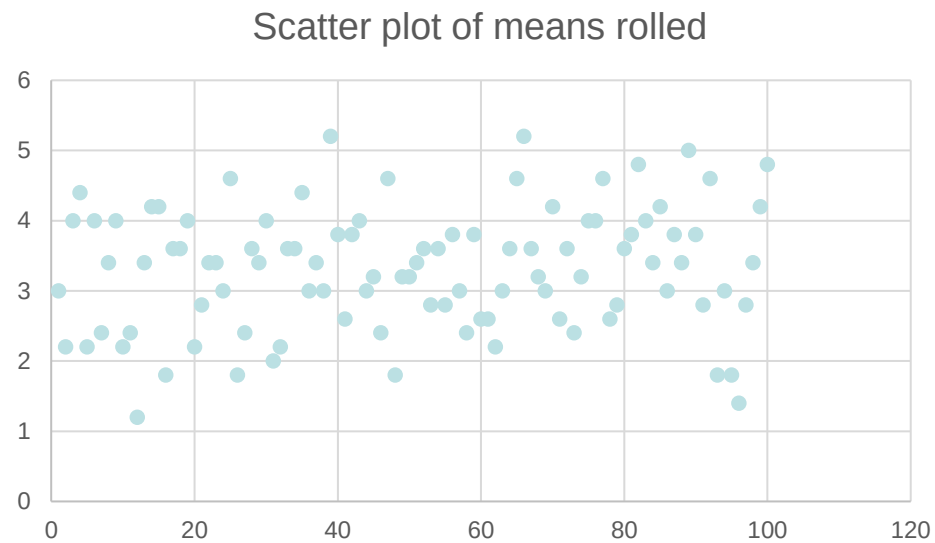


Analyse – Different Distributions



Analyse – Central Limit Theorem - example



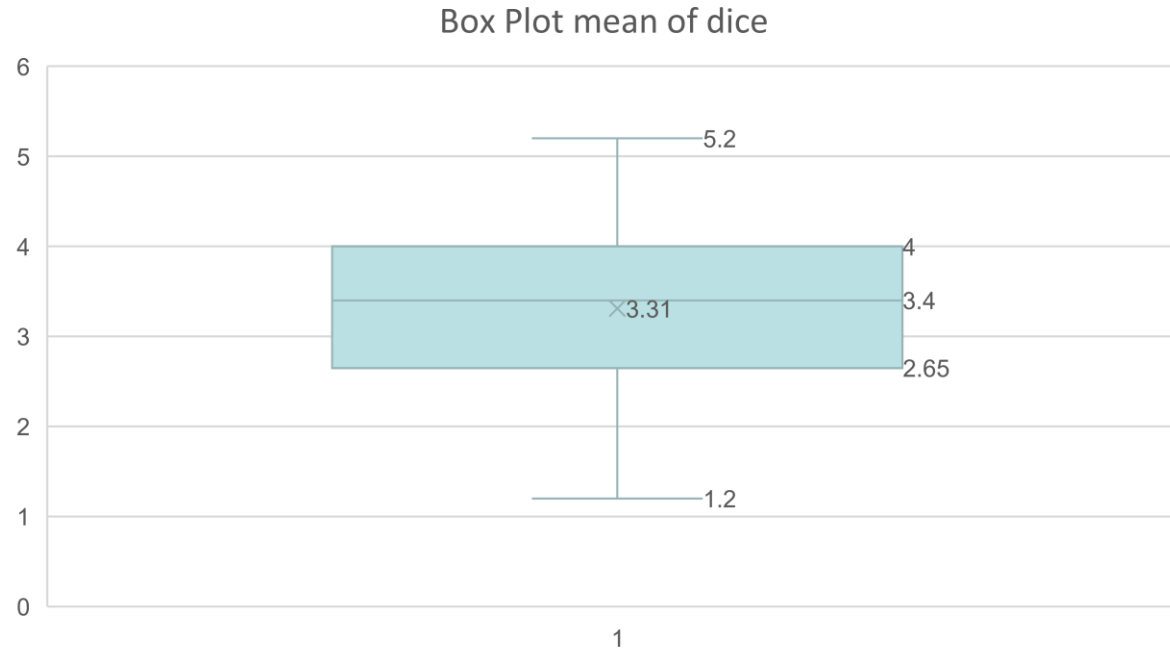


Analyse – Central Limit Theorem - example

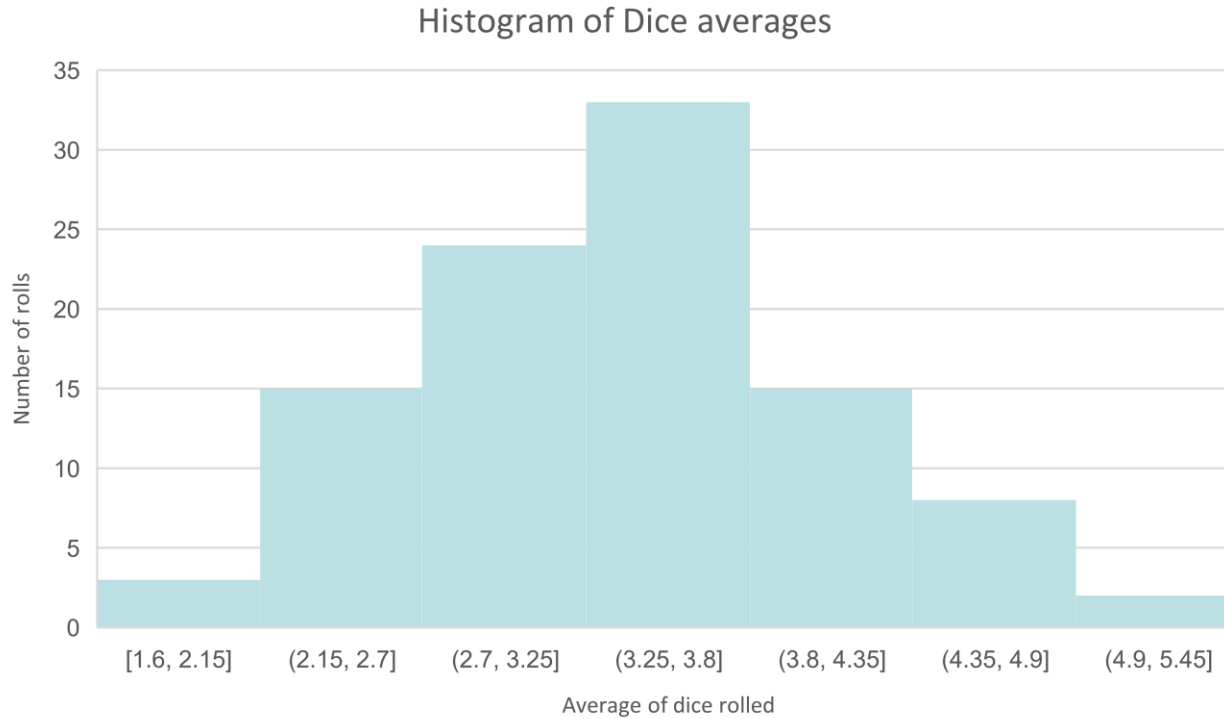
Column1	
Mean	3.31
Standard Error	0.08689364
Median	3.4
Mode	3.6
Standard Deviation	0.86893642
Sample Variance	0.75505051
Kurtosis	-0.4025302
Skewness	-0.0878595
Range	4
Minimum	1.2
Maximum	5.2
Sum	331
Count	100



Analyse – Central Limit Theorem - example



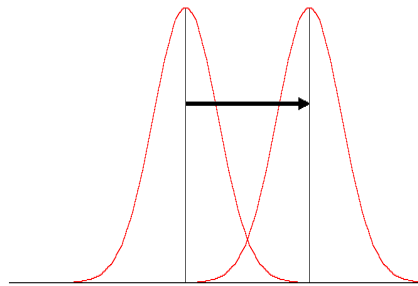
Analyse – Central Limit Theorem - example



Hypothesis testing is where we determine where specific values of interest sit within a calculated range (this range is known as the confidence interval)

If the value sits within this range, you can conclude that these are the same

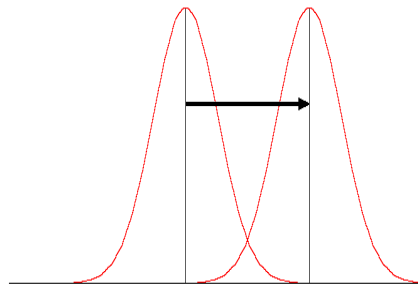
If the value sits outside the range, you can conclude that these are different



Common applications of this are:-

To see if two means are equal – two sets of data from the same population will not always be the same

This testing will highlight if there are real differences between two sets of data from the populations



The 'Null Hypothesis' H_0 is a statement to determine whether something is true or not

It is expressed as a formula

$$H_0: \mu_1 (\text{ave}) = \mu_2 (\text{ave})$$

or

$$H_0: \mu_1 (\text{ave}) - \mu_2 (\text{ave}) = 0$$

The 'Alternative Hypothesis' H_a is a statement to determine whether we can reject the null hypothesis

It is expressed as a formula

$$H_a: \mu_1 (\text{ave}) \neq \mu_2 (\text{ave})$$

or

$$H_a: \mu_1 (\text{ave}) - \mu_2 (\text{ave}) \neq 0$$