**SAMPLE MEANS**

**Extended investigation Part 1:** **Preparation activity**

Note:

For a Uniform Distribution .

For a Binomial Distribution .

The distribution formed when the following procedure is carried out is called the **sampling distribution of means**.

* Take a random sample of  independent observations from a population. If the population is finite, sampling should be with replacement to ensure that the observations are independent.
* Calculate the mean of these  sample values. This is known as the sample mean.
* Repeat the procedure until all possible samples of size  have been taken, calculating the sample mean of each one.
* Form a distribution of the sample means.

A sample value may be used to estimate an unknown population parameter by constructing an interval estimate, known as a **confidence interval**. This is an interval that has a specified probability of including the parameter. The probabilities most often used in confidence intervals are 90%, 95% and 99%. If the mean  of a particular population is unknown, then determining a 95% confidence interval for it would mean constructing the interval  such that .

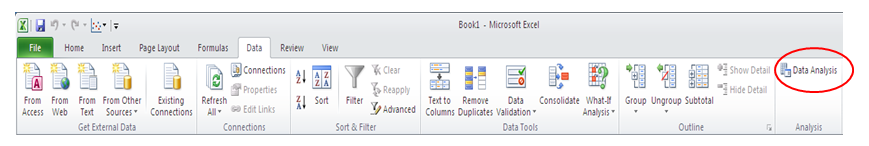
The interval constructed uses the value of the mean  of a random sample of size  taken from the population.

Before constructing a confidence interval for , the following questions need to be answered.

* Is the distribution of the population normal?
* Is the variance of the population known?
* Is the sample small or large? (Usually  is considered a large sample.)

When calculating confidence intervals it is often the case that the population standard deviation is not known. Provided that the sample size is large, the sample standard deviation  may be used as an unbiased estimate for .

Open an Excel workbook and look for **Data Analysis** on the **Data** tab.



If the **Data Analysis** command does not appear in the **Data** tab, then follow the instructions below:

1. Click the **File** tab, click **Options**, and then click the **Add-ins** category.

2. In the **Manage** box, select **Excel Add-ins** and then click **Go**.

3. In the **Add-ins available** box, select the **Analysis ToolPak** check box, and then click **OK**.

If you are prompted that the Analysis **ToolPak** is not currently installed on your computer, click **Yes** to install it.

However, there is an issue with MacBook’s, the Apple software version of Office and specifically the Excel version 2011 for Mac and 2008 for Mac, do not have the add-in, Data Analysis Tool-Pak.

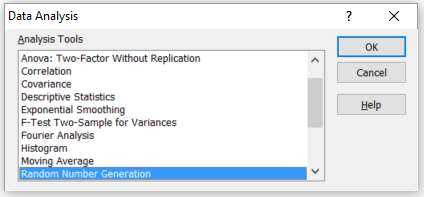
Please refer to the following link for further information about this issue

<https://support.microsoft.com/en-au/kb/2431349>

**Task One:**

Step 1: Open an Excel workbook and generate 100 samples each of size  from uniformly distributed numbers between 10 and 20, i.e. .

Method: Click on **Data Analysis** and then double click on **Random Number Generation**.



|  |  |
| --- | --- |
|  | Number of variables: sample size  Number of Random Numbers: number of samples  Distribution: select distribution  Parameter: enter parameters for distribution  Random Seed: leave blank  Output options  Output Range: insert address of first cell of generated values |

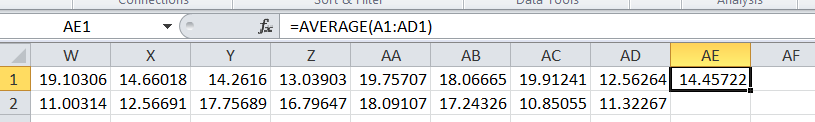
Click **OK**.

Each of the 100 rows contains 30 numbers between 10 and 20.

Step 2a: For each of the 100 samples, calculate the sample mean.

Method: Click in cell AE1 and type **=AVERAGE(A1:AD1)**

Click in cell AE1, grab the small square in the lower right hand corner of the cell and fill down to cell AE100.



Step 2b: For each of the 100 samples, calculate the sample standard deviation.

Method: Click in cell AF1 and type **=STDEV.S(A1:AD1)**

Click in cell AF1, grab the small square in the lower right hand corner of the cell and fill down to cell AF100.

Step 3a: Calculate the mean of the sample means, .

Method: Click in cell AE101 and type **=AVERAGE(AE1:AE100)**

Step 3b: Calculate the standard deviation of the sample means, .

Method: Click in cell AE102 and type **=STDEV.P(AE1:AE100)**

Step 3c: Record the sample size, the number of samples, the type of distribution (including the distribution parameters), the mean of the sample means and the standard deviation of the sample means.

Step 4: For each sample, construct the 95% confidence interval for the population mean . Since the samples were not taken from a Normal population, the variance of the population is known and the sample size is large, a 95% confidence interval is given by , where  is the sample mean,  is the population standard deviation and  is the sample size.

Method: Click in cell AG1 and type **=AE1-1.96\*(10/SQRT(12))/SQRT(30) *(verify this formula with the confidence interval above)***

Click in cell AG1, grab the small square in the lower right hand corner of the cell and fill down to cell AG100.

Click in cell AH1 and type **= AE1+1.96\*(10/SQRT(12))/SQRT(30)**

***(verify this formula with the confidence interval above)***

Click in cell AH1, grab the small square in the lower right hand corner of the cell and fill down to cell AH100.

Step 5a: For each sample, test whether or not the population mean lies within the 95% confidence interval.

Method: Click in cell AI1 and type **=IF(AND(15>AG1,15<AH1),1,0)**

Click in cell AI1, grab the small square in the lower right hand corner of the cell and fill down to cell AI100.

If the population mean lies within the 95% confidence interval the value 1 is returned, if not the value of 0 is returned.

Step 5b: Determine how many of the 95% confidence intervals contain the population mean.

Method: Click in cell AI101 and type **=SUM(AI1:AI100)**

Step 6: Arrange the values of the sample means that are currently in AE1 to AE100 into intervals 13 to 13.25, 13.25 to 13.5, …, 16.5 to 16.75, 16.75 to 17 and draw a histogram.

Method: Click in cell AM1 and type **13**

Click in cell AM2 and type **=AM1+0.25**

Click in cell AM2, grab the small square in the lower right hand corner of the cell and fill down to cell AM17. (Cell AM17 should show the value 17.)

Click on **Data Analysis** and then double click on **Histogram**.

|  |  |
| --- | --- |
|  | Input Range: AE1 to AE100  Bin Range: AM1 to AM17  Output options  New Worksheet Ply:  Check Chart Output |

Click **OK**.

Click on the word **Bin** and press **Delete**.

To remove the space between the bars, right click on a bar, select **Format Data Series** and change the **Gap Width** to 0%. Select **Border Color** to add a border.

Step 7a: For each sample, calculate .

Method: Click in cell AJ1 and type **=(AE1-15)/((10/SQRT(12))/SQRT(30))**

***(verify this formula with the rule above)***

Click in cell AJ1, grab the small square in the lower right hand corner of the cell and fill down to cell AJ100.

Step 7b: Calculate the mean of these  values.

Method: Click in cell AJ101 and type **=AVERAGE(AJ1:AJ100)**

Step 7c: Calculate the standard deviation of these  values.

Method: Click in cell AJ102 and type **=STDEV.P(AJ1:AJ100)**

Step 8: Arrange the values  that are currently in AJ1 to AJ100 into intervals 3.5 to -3, -3 to -2.5, -2.5 to -2, …, 2.5 to 3, 3 to 3.5 and draw a histogram.

Method: Click in cell AK1 and type **-3.5**

Click in cell AK2 and type **=AK1+0.5**

Click in cell AK2, grab the small square in the lower right hand corner of the cell and fill down to cell AK15. (Cell AK15 should show the value 3.5.)

Click on **Data Analysis** and then double click on **Histogram**.

|  |  |
| --- | --- |
|  | Input Range: AJ1 to AJ100  Bin Range: AK1 to AK15  Output options  New Worksheet Ply:  Check Chart Output |

Click **OK**.

Click on the word **Bin** and press **Delete**.

To remove the space between the bars, right click on a bar, select **Format Data Series** and change the **Gap Width** to 0%. Select **Border Color** to add a border.

**It is often the case that the population standard deviation  is not known. Provided that the sample size is large, the sample standard deviation  may be used as an unbiased estimate for . Steps 4, 5, 7 and 8 will be repeated using  instead of .**

Step 9: For each sample, construct the 95% confidence interval for the population mean  using , where  is the sample mean,  is the sample standard deviation and  is the sample size.

Method: Click in cell AO1 and type **=AE1-1.96\*AF1/SQRT(30)**

Click in cell AO1, grab the small square in the lower right hand corner of the cell and fill down to cell AO100.

Click in cell AP1 and type **= AE1+1.96\*AF1/SQRT(30)**

Click in cell AP1, grab the small square in the lower right hand corner of the cell and fill down to cell AP100.

Step 10a: For each sample, test whether or not the population mean lies within the 95% confidence interval.

Method: Click in cell AQ1 and type **=IF(AND(15>AO1,15<AP1),1,0)**

Click in cell AQ1, grab the small square in the lower right hand corner of the cell and fill down to cell AQ100.

If the population mean lies within the 95% confidence interval the value 1 is returned, if not the value of 0 is returned.

Step 10b: Determine how many of the 95% confidence intervals contain the population mean.

Method: Click in cell AQ101 and type **=SUM(AQ1:AQ100)**

Step 11a: For each sample, calculate .

Method: Click in cell AR1 and type **=(AE1-15)/(AF1/SQRT(30))**

Click in cell AR1, grab the small square in the lower right hand corner of the cell and fill down to cell AR100.

Step 11b: Calculate the mean of these  values.

Method: Click in cell AR101 and type **=AVERAGE(AR1:AR100)**

Step 11c: Calculate the standard deviation of these  values.

Method: Click in cell AR102 and type **=STDEV.P(AR1:AR100)**

Step 12: Arrange the values  that are currently in AR1 to AR100 into intervals -3.5 to -3, -3 to -2.5, -2.5 to -2, …, 2.5 to 3, 3 to 3.5 and draw a histogram.

Click on **Data Analysis** and then double click on **Histogram**.

|  |  |
| --- | --- |
|  | Input Range: AR1 to AR100  Bin Range: AK1 to AK15  Output options  New Worksheet Ply:  Check Chart Output |

Click **OK**.

Click on the word **Bin** and press **Delete**.

To remove the space between the bars, right click on a bar, select **Format Data Series** and change the **Gap Width** to 0%. Select **Border Color** to add a border.

**Task One Questions**

1 In Step 2a, the mean  of each of the 100 samples of size  was calculated. Do each of your samples have the same sample mean or does this value vary between the samples?

2 (a) Calculate the population mean  for .

(b) In Step 3a, the mean of the 100 sample means was calculated. Compare your answer with the value of .

3 In Step 2b, the standard deviation  of each of the 100 samples of size  was calculated. Do each of your samples have the same sample standard deviation or does this value vary between the samples?

4 (a) Calculate the population standard deviation  for .

(b) In Step 3b, the standard deviation of the 100 sample means was calculated. Why is the standard deviation of the 100 sample means less than the population standard deviation ?

5 In Step 4, 95% confidence intervals for  were constructed using whilst in Step 5 each confidence interval was tested to determine whether or not  was within the interval. What percentage of the confidence intervals contained ?

6 In Step 6, a histogram was drawn using the values of the sample means. What do you notice about the shape of this distribution?

7 In Step 7a, the value of was calculated for each sample. In Steps 7b and 7c, the mean and standard deviation of the values of  were calculated. What do you notice about the mean and standard deviation of ?

8 In Step 8, a histogram was drawn using the values of . What do you notice about the shape of this distribution?

9 In Step 9, 95% confidence intervals for  were constructed using whilst in Step 10 each confidence interval was tested to determine whether or not  was within the interval. What percentage of the confidence intervals contained ?

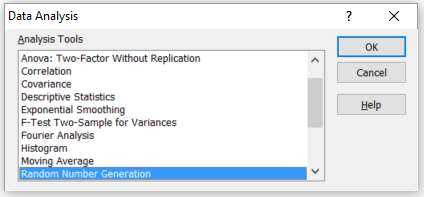
10 In Step 11a, the value of  was calculated for each sample. In Steps 11b and 11c, the mean and standard deviation of the values of  were calculated. What do you notice about the mean and standard deviation of ?

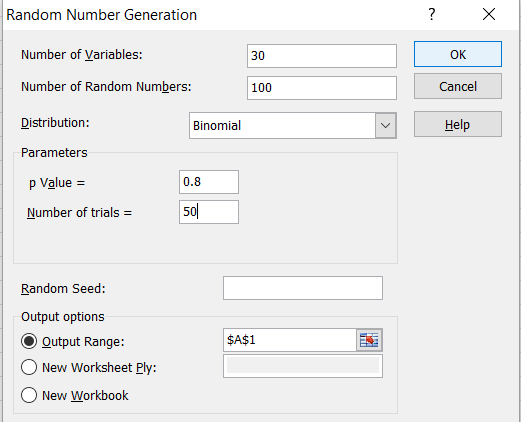
11 In Step 12, a histogram was drawn using the values of . What do you notice about the shape of this distribution?

**Repeat Task One (include answering the eleven Task One Questions) using different Uniform Distributions, different sample sizes ensuring , and different numbers of samples. In Step 6, arrange the sample means into appropriate intervals and then draw the histogram.**

**Task Two:**

Step 1 Using and Excel workbook, generate 100 samples each of size 30 from the binomial distribution .





Step 2 For each of the 100 samples, calculate the sample mean and the sample standard deviation.

Step 3 Calculate the mean of the sample means, , and the standard deviation of the sample means, . Record the sample size, the number of samples, type of distribution, the mean of the sample means and the standard deviation of the sample means.

Step 4 For each sample, construct the 95% confidence interval for the population mean  using , where  is the sample mean,  is the population standard deviation and  is the sample size.

***(verify that your excel formula matches the confidence interval above)***

Step 5 For each sample, test whether or not the population mean lies within the 95% confidence interval . Determine how many of the 95% confident intervals contain the population mean.

Step 6 Arrange the sample means into appropriate intervals and draw a histogram.

Step 7 For each sample, calculate . Calculate the mean and the standard deviation of the  values.

Step 8 Arrange the values  into intervals -3.5 to -3, -3 to -2.5, -2.5 to -2, …, 2.5 to 3, 3 to 3.5 and draw a histogram.

**It is often the case that the population standard deviation  is not known. Provided that the sample size is large, the sample standard deviation  may be used as an unbiased estimate for . Steps 4, 5, 7 and 8 will be repeated using  instead of .**

Step 9: For each sample, construct the 95% confidence interval for the population mean  using , where  is the sample mean,  is the sample standard deviation and  is the sample size.

Step 10: For each sample, test whether or not the population mean lies within the 95% confidence interval . Determine how many of the 95% confident intervals contain the population mean.

Step 11: For each sample, calculate . Calculate the mean and the standard deviation of the  values.

Step 12: Arrange the values  that are currently in AR1 to AR100 into intervals -3.5 to -3, -3 to -2.5, -2.5 to -2, …, 2.5 to 3, 3 to 3.5 and draw a histogram.

**Task Two Questions**

1 In Step 2, the mean  of each of the 100 samples of size  was calculated. Do each of your samples have the same sample mean or does this value vary between the samples?

2 (a) Calculate the population mean  for .

(b) In Step 3, the mean of the 100 sample means was calculated. Compare your answer with the value of .

3 In Step 2, the standard deviation  of each of the 100 samples of size  was calculated. Do each of your samples have the same sample standard deviation or does this value vary between the samples?

4 (a) Calculate the population standard deviation  for .

(b) In Step 3, the standard deviation of the 100 sample means was calculated. Why is the standard deviation of the 100 sample means less than the population standard deviation ?

5 In Step 4, 95% confidence intervals for  were constructed using whilst in Step 5, each confidence interval was tested to determine whether or not  was within the interval. What percentage of the confident intervals contained ?

6 In Step 6, a histogram was drawn using the values of the sample means. What do you notice about the shape of this distribution?

7 In Step 7, the value of was calculated for each sample and the mean and standard deviation of the values of  were calculated. What do you notice about the mean and standard deviation of ?

8 In Step 8, a histogram was drawn using the values of . What do you notice about the shape of this distribution?

9 In Step 9, 95% confidence intervals for  were constructed using whilst in Step 10 each confidence interval was tested to determine whether or not  was within the interval. What percentage of the confidence intervals contained ?

10 In Step 11, the value of  was calculated for each sample and the mean and standard deviation of the values of  were calculated. What do you notice about the mean and standard deviation of ?

11 In Step 12, a histogram was drawn using the values of . What do you notice about the shape of this distribution?

**Repeat Task Two (include answering the eleven Task Two Questions) using different Binomial Distributions, different sample sizes ensuring , and different numbers of samples. In Step 6, arrange the sample means into appropriate intervals and then draw the histogram.**

**Task Three Questions**

In Tasks One and Two, you recorded the sample size, the number of samples, type of distribution, the mean of the sample means and the standard deviation of the sample means.

1. What do you notice about the mean of the sample means, , and the mean of the population, ?

2. What do you notice about the standard deviation of the sample means, , and the standard deviation of the population, ?

3. Complete the following:

“*When random samples are taken from a non-normal population with mean  and known variance , the distribution of  is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ and \_\_\_\_\_\_\_\_\_\_\_\_ provided that \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.*”

4. Complete the following:

“*When random samples are taken from a non-normal population with mean  and unknown variance, the distribution of  is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ and \_\_\_\_\_\_\_\_\_\_\_\_ provided that \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.*”

**SAMPLE MEANS**

**Extended investigation Part 1:** **Preparation activity**

**Solutions**

**Task One Questions**

**1**

|  |
| --- |
| Solution |
| The value varies between samples. |

**2(a)**

|  |
| --- |
| Solution |
|  |

**2(b)**

|  |
| --- |
| Solution |
| Answers will vary; however, the mean of the sample means should be similar to the population mean. |

**3**

|  |
| --- |
| Solution |
| The value varies between samples. |

**4(a)**

|  |
| --- |
| Solution |
|  |

**4(b)**

|  |
| --- |
| Solution |
| The standard deviation of the sample means is less than the population standard deviation because there is less variability amongst the sample means due to the sample means being more clustered around  than the population values are.  The larger the sample size, the more clustered the sample means are about the mean; consequently, the larger the sample size, the smaller the standard deviation of the sample means. |

**5**

|  |
| --- |
| Solution |
| Answers will vary; however, approximately 95% of the confidence intervals should contain the population mean. |

**6**

|  |
| --- |
| Solution |
| For large values of  the distribution of the sample means is approximately normal. |

**7**

|  |
| --- |
| Solution |
| Answers will vary; however, the mean of  should be close to zero and the standard deviation close to one. |

**8**

|  |
| --- |
| Solution |
| For large values of  the distribution of  is approximately normal. |

**9**

|  |
| --- |
| Solution |
| Answers will vary; however, approximately 95% of the confidence intervals should contain the population mean. |

**10**

|  |
| --- |
| Solution |
| Answers will vary; however, the mean of  should be close to zero and the standard deviation close to one. |

**11**

|  |
| --- |
| Solution |
| For large values of  the distribution of  is approximately normal. |

**Task Two Questions**

**1**

|  |
| --- |
| Solution |
| The value varies between samples. |

**2(a)**

|  |
| --- |
| Solution |
|  |

**2(b)**

|  |
| --- |
| Solution |
| Answers will vary; however, the mean of the sample means should be similar to the population mean. |

**3**

|  |
| --- |
| Solution |
| The value varies between samples. |

**4(a)**

|  |
| --- |
| Solution |
|  |

**4(b)**

|  |
| --- |
| Solution |
| The standard deviation of the sample means is less than the population standard deviation because there is less variability amongst the sample means due to the sample means being more clustered around  than the population values are.  The larger the sample size, the more clustered the sample means are about the mean; consequently, the larger the sample size, the smaller the standard deviation of the sample means. |

**5**

|  |
| --- |
| Solution |
| Answers will vary; however, approximately 95% of the confidence intervals should contain the population mean. |

**6**

|  |
| --- |
| Solution |
| For large values of  the distribution of the sample means is approximately normal. |

**7**

|  |
| --- |
| Solution |
| Answers will vary; however, the mean of  should be close to zero and the standard deviation close to one. |

**8**

|  |
| --- |
| Solution |
| For large values of  the distribution of  is approximately normal. |

**9**

|  |
| --- |
| Solution |
| Answers will vary; however, approximately 95% of the confidence intervals should contain the population mean. |

**10**

|  |
| --- |
| Solution |
| Answers will vary; however, the mean of  should be close to zero and the standard deviation close to one. |

**11**

|  |
| --- |
| Solution |
| For large values of  the distribution of  is approximately normal. |

**Task Three Questions**

**1**

|  |
| --- |
| Solution |
| The mean of the sample means are similar to the population mean. |

**2**

|  |
| --- |
| Solution |
| The standard deviation of the sample means is less than the population standard deviation because there is less variability amongst the sample means due to the sample means being more clustered around  than the population values are.  The larger the sample size, the more clustered the sample means are about the mean; consequently, the larger the sample size, the smaller the standard deviation of the sample means. |

**3**

|  |
| --- |
| Solution |
| “*When random samples are taken from a non-normal population with mean  and known variance , the distribution of is approximately normal and  provided that the sample size, , is large.*” |

**4**

|  |
| --- |
| Solution |
| “*When random samples are taken from a non-normal population with mean  and unknown variance, the distribution of is approximately normal and  provided that the sample size, , is large.*” |

**Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**SAMPLE MEANS**

**Extended investigation Part 2: In-class validation (33 marks)**

Note: For .

For .

**Question 1 (3 marks)**

By determining the amount of fat for a random sample of 64 hamburgers of a particular fast food chain, Patty determined that a 95% confidence interval for the population mean fat content  in hamburgers served by this fast food chain is  grams.

Answer the following questions with “Yes,” “No,” or “Cannot tell” and justify your answer.

(a) Does the population mean lie in the interval ? (1)

(b) Does the sample mean lie in the interval ? (1)

(c) For a greater confidence, say, 99%, will the confidence interval calculation from the same data produce an interval narrower than ? (1)

**Question 2 (3 marks)**

Given that a 95% confidence interval for the population mean calculated using a sample of size 30 from a uniform distribution is , determine the sample mean and the population standard deviation.

**Question 3 (2 marks)**

The following diagrams illustrate the distribution of  for samples of different sizes taken from a population . Given , identify the distribution of  for samples of size 5, 15 and 50.

Diagram A Diagram B

Diagram C

**Question 4 (7 marks)**

Random samples of size forty are taken from each of the following distributions and the sample mean is calculated. Find, in each case, the probability that the sample mean is less than 4.5.

(a)  is the number of heads obtained when an unbiased coin is tossed ten times. (4)

(b)  is distributed uniformly throughout the range . (3)

**Question 5 (13 marks)**

(a) The distribution of the random variable  is  and  is the mean of a random sample of size  drawn from this distribution. Assuming that  is large, find the value of  given that . (7)

(b) The distribution of a random variable  is . A large number of random samples of size  are taken from this distribution. Approximately 90% of the sample means are less than 5.14. Estimate . (6)

**Question 6 (5 marks)**

The time that customers take to complete their transaction at an ATM is a random variable with mean 3 minutes and standard deviation 0.6 minutes. Determine the probability that a random sample of 40 customers will take between 90 and 125 minutes to complete all their transactions.

**SAMPLE MEANS**

**Extended investigation Part 2: In-class validation**

**Solutions and marking key**

**Question 1(a)**

|  |  |
| --- | --- |
| Solution | |
| Cannot tell.  The probability that the population mean lies in this interval is 0.95. There is a 5% chance that the interval does not include the population mean. | |
| Mathematical behaviours | Marks |
| * Correct response with justification | 1 |

**Question 1(b)**

|  |  |
| --- | --- |
| Solution | |
| Yes  The interval is calculated using the sample mean,  where  is the sample standard deviation. | |
| Mathematical behaviours | Marks |
| * Correct response with justification | 1 |

**Question 1(c)**

|  |  |
| --- | --- |
| Solution | |
| No, the interval will be wider.  The interval is calculated using the sample mean, , where . | |
| Mathematical behaviours | Marks |
| * Correct response with justification | 1 |

**Question 2**

|  |  |
| --- | --- |
| Solution | |
| Using CAS, | |
| Mathematical behaviours | Marks |
| * Chooses * Correct sample mean * Correct population standard deviation | 1  1  1 |

**Question 3**

|  |  |
| --- | --- |
| Solution | |
| Diagram A: means of samples size 15  Diagram B: means of samples size 5  Diagram C: means of samples size 50 | |
| Mathematical behaviours | Marks |
| * Correctly identifies one distribution * Correctly identifies a second distribution | 1  1 |

**Question 4(a)**

|  |  |
| --- | --- |
| Solution | |
| Since  is large, , where . | |
| Mathematical behaviours | Marks |
| * Correctly justifies choice of sampling distribution for * Correctly calculates * Correctly calculates * Correct probability | 1  1  1  1 |

**Question 4(b)**

|  |  |
| --- | --- |
| Solution | |
| Since  is large, , where . | |
| Mathematical behaviours | Marks |
| * Correctly calculates * Correctly calculates * Correct probability | 1  1  1 |

**Question 5(a)**

|  |  |
| --- | --- |
| Solution | |
| Since  is large, , where      Since , then    Hence, | |
| Mathematical behaviours | Marks |
| * Correctly justifies choice of sampling distribution for * Correctly calculates * Correctly calculates * Rewrites probability in terms of * Determines correct standardised value * Calculates * Correctly rounds  to integer value | 1  1  1  1  1  1  1 |

**Question 5(b)**

|  |  |
| --- | --- |
| Solution | |
| Since  is large, , where      Since , then    Hence, | |
| Mathematical behaviours | Marks |
| * Correctly calculates * Correctly calculates * Rewrites probability in terms of * Determines correct standardised value * Calculates * Correctly rounds  to integer value | 1  1  1  1  1  1 |

**Question 6**

|  |  |
| --- | --- |
| Solution | |
| : time in minutes that a customer takes to complete their transaction.  Since  is large, , where . | |
| Mathematical behaviours | Marks |
| * Defines the random variable * Correctly justifies choice of sampling distribution for * Correctly states the value of  and * Calculates the average times * Correct probability | 1  1  1  1  1 |