Example 1: The data file Score.xlsx has final scores for STATS 101 class at a university. Test if the true mean μ for STATS 101 class equals 90.

This problem is formulated as testing H_0: $\mu = 90$ vs. H_1: $\mu \neq 90$.

Run MINITAB, open data file Score.xlsx. Once data file opens in MINITAB (or copy and paste data into a MINITAB worksheet), then click on the sequence

Stat/Basic Statistics/1-Sample t (Figure 1a) then select Score as the variable, check Perform hypothesis test box, enter 90 in the Hypothesized mean box, and click OK (if your hypothesis is 1-way, click Options box, select alternative; see Figure 1b)

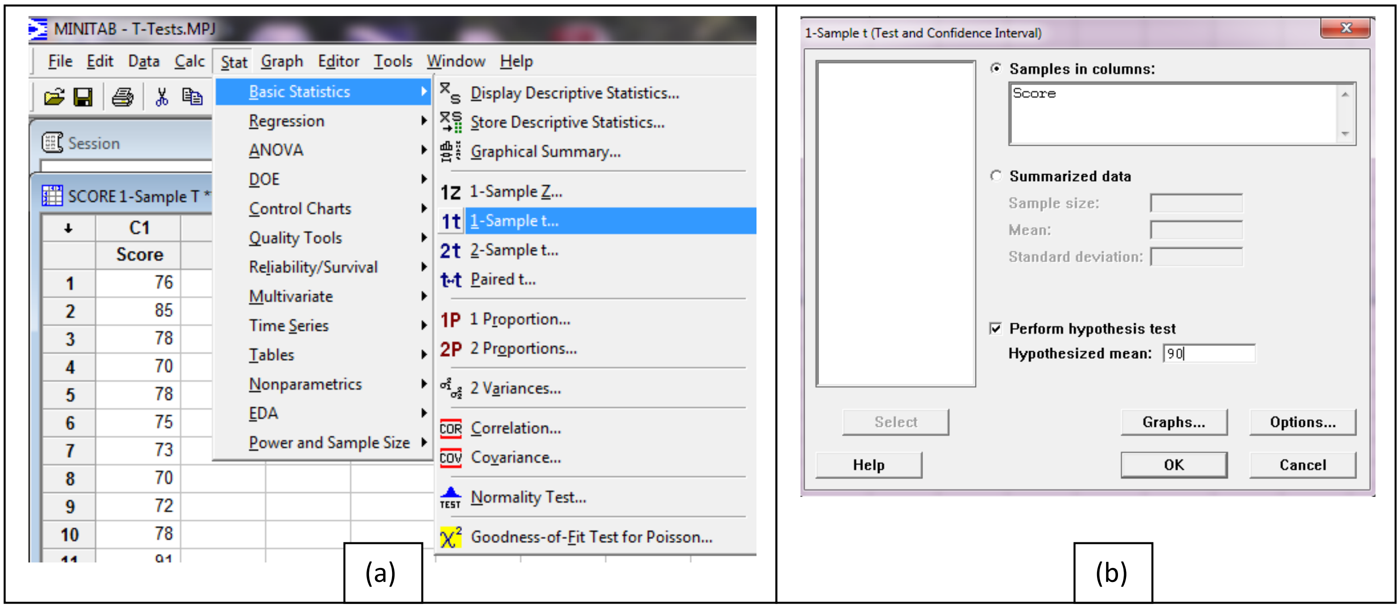


Figure 1: Running 1-Sample T-Test in MINITAB

The output from MINITAB is given below:

One-Sample T: Score

```
Test of mu = 90 vs not = 90

Variable   N     Mean    StDev  SE Mean        95% CI              T      P
Score     60  74.8833  10.6167   1.3706  (72.1407, 77.6259)  -11.03  0.000
```

Since P-value = 0.000 < .05, the null hypothesis is rejected. Moreover, the confidence interval (72.1407, 77.6259) does not contain the hypothesized mean of 90, which implies that the null hypothesis is rejected.

One of the assumptions of 1-sample t-test is that the sample be normally distributed (or sample size n be sufficiently large, typically $n \geq 30$ is considered a large sample). We now show how to assess the normality of a sample in MINITAB. Click on:

Stat/Basic Statistics/Normality Test (Figure 1c), then select Score as variable and click on Kolmogorov-Smirnov Test for Normality (Figure 1d).

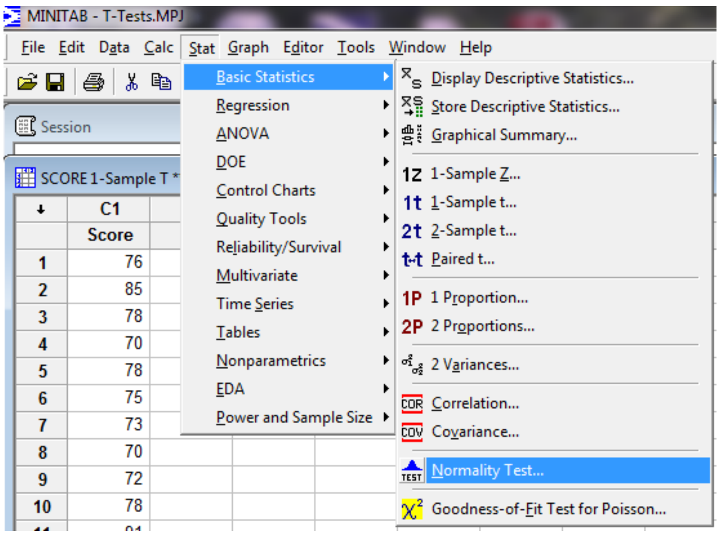


Figure 1c: Running Test of Normality in MINITAB

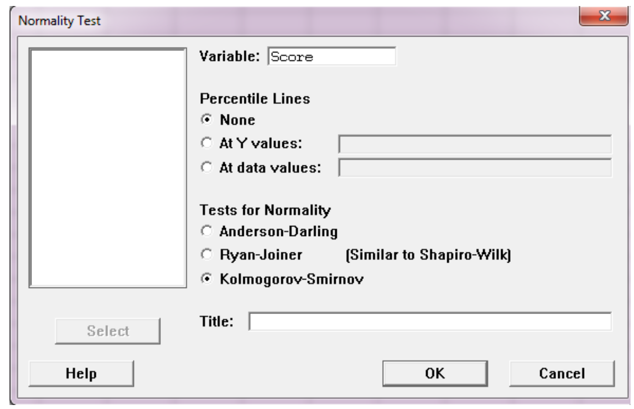
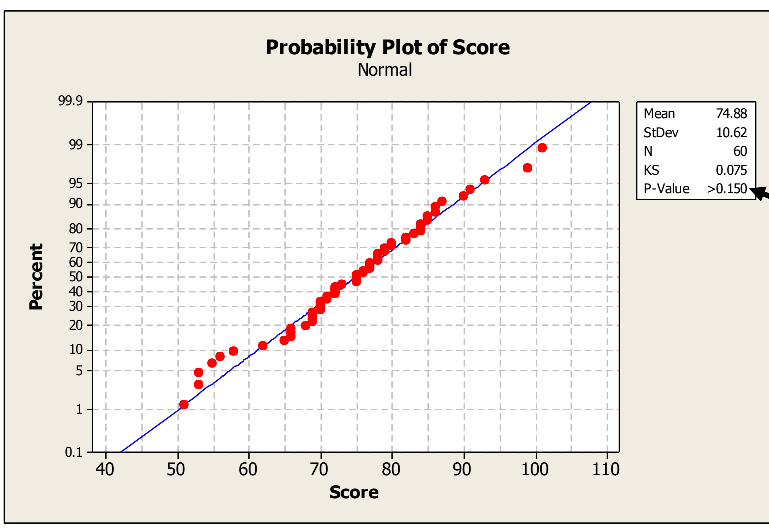


Figure 1d: Select Score in Variables Box, and Kolmogorov-Smirnov Test for Normality

MINITAB will produce the following Quantile-Quantile Plot of the variable Score (Figure 1e). Since the pairs of points on the graph plot along the line Y = X, the sample (Score) appears to come from a normally distributed population.



Since the P-value of K-S Test > .05, the null hypothesis of normality of the sample is not rejected, and the results of t-test are valid.

Figure 1e: Q-Q Plot for Score from MINITAB

Example 2: Measured weights 0f 20 '3 lbs hamburger meat' packets from Grocery store A and 15 from Grocery Store B are given in the data file Weights.xlsx. Test if the true means of '3 lbs hamburger meat' packets from Grocery store A and Grocery Store B are equal.

The null hypothesis H_0: $\mu_1 = \mu_2$ is to be tested vs. the alternative H_1: $\mu_1 \neq \mu_2$. The T-Test depends on whether the two population variances are equal, or unequal. Instead of testing the equality of the two population variances, we will run the T-Test for comparing two means first assuming that both population variances are equal, and then assuming that they are unequal.

<u>Equal Variances Cases:</u>

- Open the data file Weights.xlsx in excel in MINITAB, or copy data and paste into a MINITAB worksheet.
- Then click the sequence Stat/Basic Statistics/2-Sample t
- Select 'Samples in different columns', select A as the First Sample, B as the second sample, check 'Assume equal variances' box (Figure 1f) then click OK.

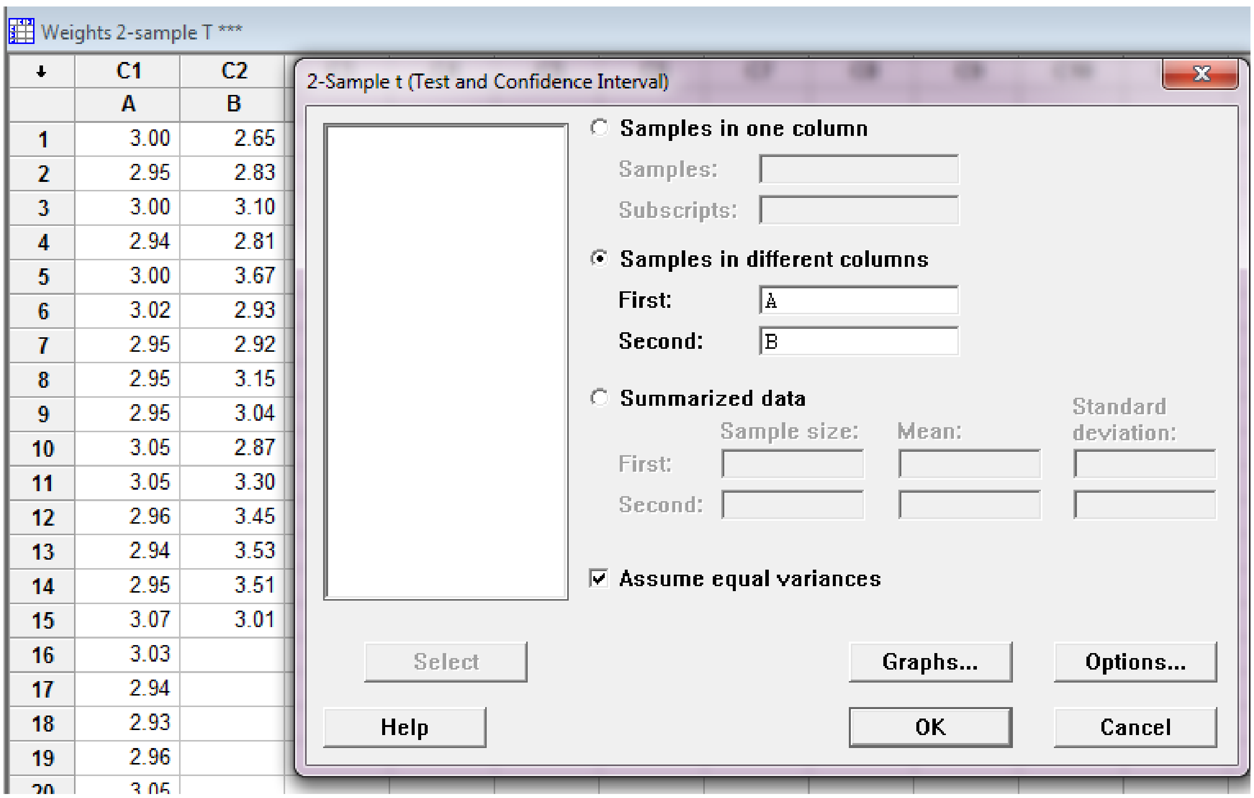


Figure 1f: Running 2-sample T-Test in MINITAB assuming Equal Variances

This will produce the output shown below:

Two-Sample T-Test and CI: A, B

```
Two-sample T for A vs B

    N    Mean   StdDev  SE Mean
A  20  2.9845  0.0461    0.010
B  15   3.118   0.307    0.079


Difference = mu (A) - mu (B)
Estimate for difference:  -0.133500
95% CI for difference:  (-0.274768, 0.007768)
T-Test of difference = 0 (vs not =): T-Value = -1.92  P-Value = 0.063  DF = 33
Both use Pooled StDev = 0.2033
```

Repeat the above steps, this time leaving the 'Assume equal variances' box unchecked (Figure 1g).

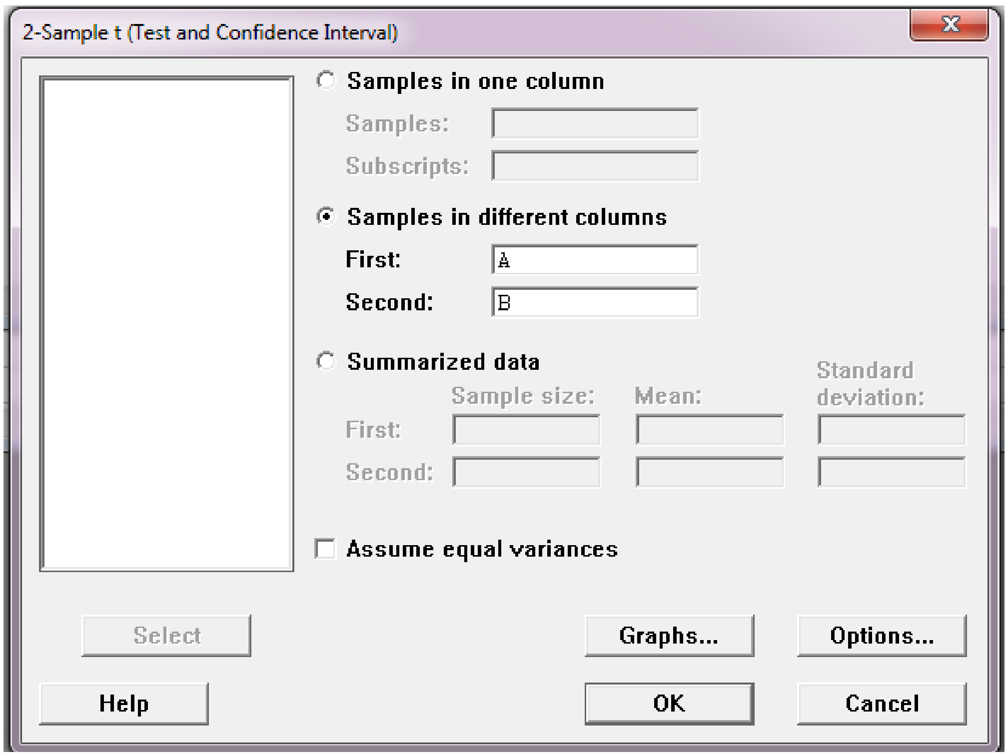


Figure 1g : Running 2-sample T-Test in MINITAB without assuming Equal Variances

The output from MINITAB is shown below.

Two-Sample T-Test and CI: A, B

```
Two-sample T for A vs B

    N    Mean   StDev  SE Mean
A  20  2.9845  0.0461    0.010
B  15   3.118   0.307    0.079


Difference = mu (A) - mu (B)
Estimate for difference:  -0.133500
95% CI for difference:  (-0.305192, 0.038192)
T-Test of difference = 0 (vs not =): T-Value = -1.67  P-Value = 0.118  DF = 14
```

From the MINITAB outputs, we see that the P-values for the null hypothesis of equal means against the 2-sided alternative are:

P = 0.063 (Assuming that the two populatin variances are equal)
P = 0.118 (Assuming that the two populatin variances are not equal)

Since the P-value in either case is > .05, the null hypothesis of equal means is not rejected.

Example 3: The data file Burger_Sales.xlsx shows daily sales of two adjacent fast food places for 14 randomly selected days. Test to see if the average sales of the two fast food restaurants are equal.

The data in this example is PAIRED since the *sales for the two restaurants are for same day, and we will need to run the paired T Test for this example.*

Open the data file Burger_Sales.xlsx in MINITAB.
Click on the sequence   Stat/Basic Statistics/Paired-Samples T Test (Figure 3a)
Select variables for 1st Paired Variable (Figure 3b) and click on OK to obtain the output shown after the figures.

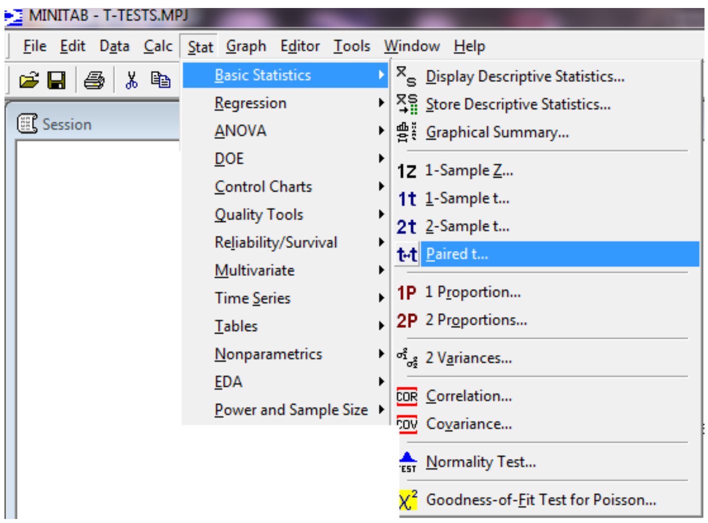


Figure 2a: Running the Paired T Test in MINITAB

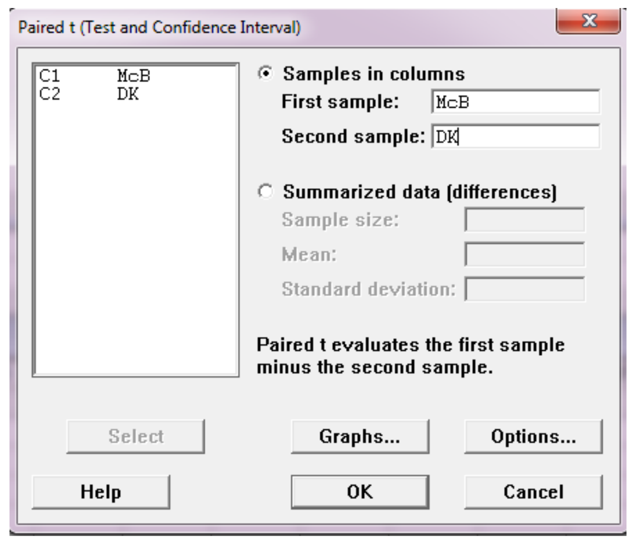


Figure 1b: Selecting Variables in the Paired T Test in MINITAB

Paired T-Test and CI: McB, DK

```
Paired T for McB - DK

             N     Mean     StDev   SE Mean
McB         14  914.433   193.752    51.782
DK          14  821.121   230.692    61.655
Difference  14  93.3114  146.9853   39.2835


95% CI for mean difference: (8.4447, 178.1782)
T-Test of mean difference = 0 (vs not = 0): T-Value = 2.38  P-Value = 0.034
```

Since the Confidence Interval for $\mu_1 - \mu_2$ = (8.44, 178.18) falls to the right of 0, we can conclude that $\mu_1 > \mu_2$

P-value = 0.034 < .05 so we reject the null hypothesis of equal means.

For the paired t-test, we need to verify the normality of the difference DIFF = McB – DK.

To calculate the variable DIFF = McB - DK in MINITAB, click on Calc/Calculator, name the variable as DIFF, then enter the Expression (McB - DK), and click OK (see Figure 3c); this will create a variable column DIFF in the MINITAB worksheet.

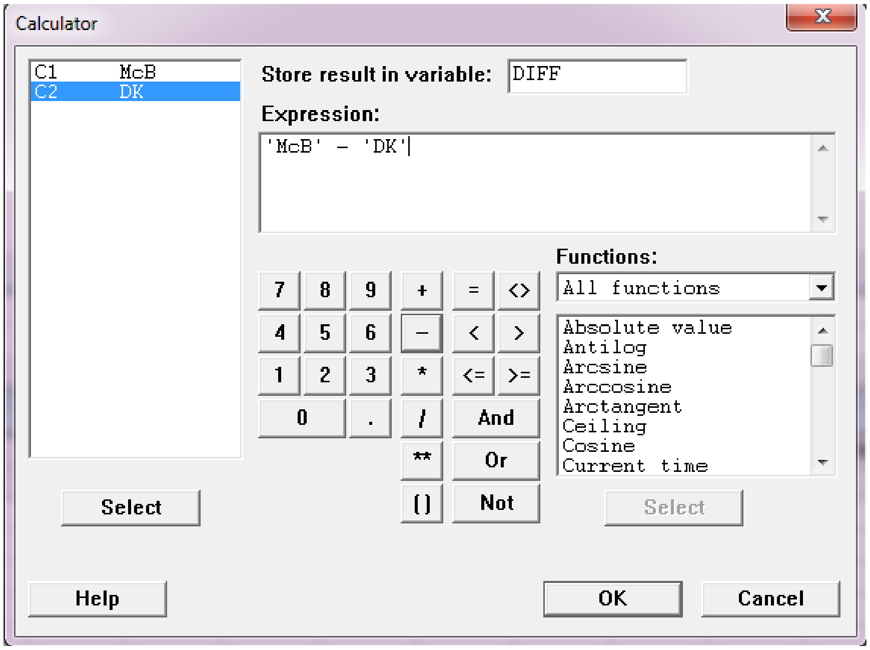
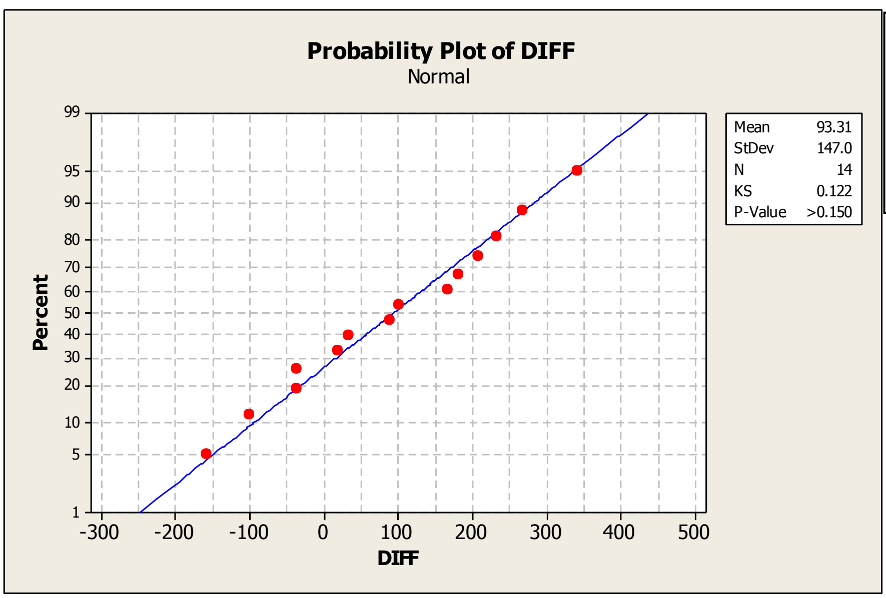


Figure 3c: Calculating difference McB - DK in MINITAB

To test normality of DIFF, click on Stat/Basic Statistics/Normality Test, select DIFF as the variable and Kolmogorov-Smirnov Test of Normality, then click OK to obtain the Probability Plot of Figure 3d.



Since the points in the Probability Plot for DIFF fall along Y=X line, the differences are normally distributed and the results of paired T Test are valid.

Figure 3c: Calculating difference McB - DK in MINITAB