Instructions for carrying out statistical procedures and tests using Minitab

These instructions are closely linked to the author's book:

Essential Statistics for the Pharmaceutical Sciences
John Wiley & Sons Ltd http://eu.wiley.com
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For all references to chapters or tables, see the above book.

Using Minitab to perform a two-way analysis of variance

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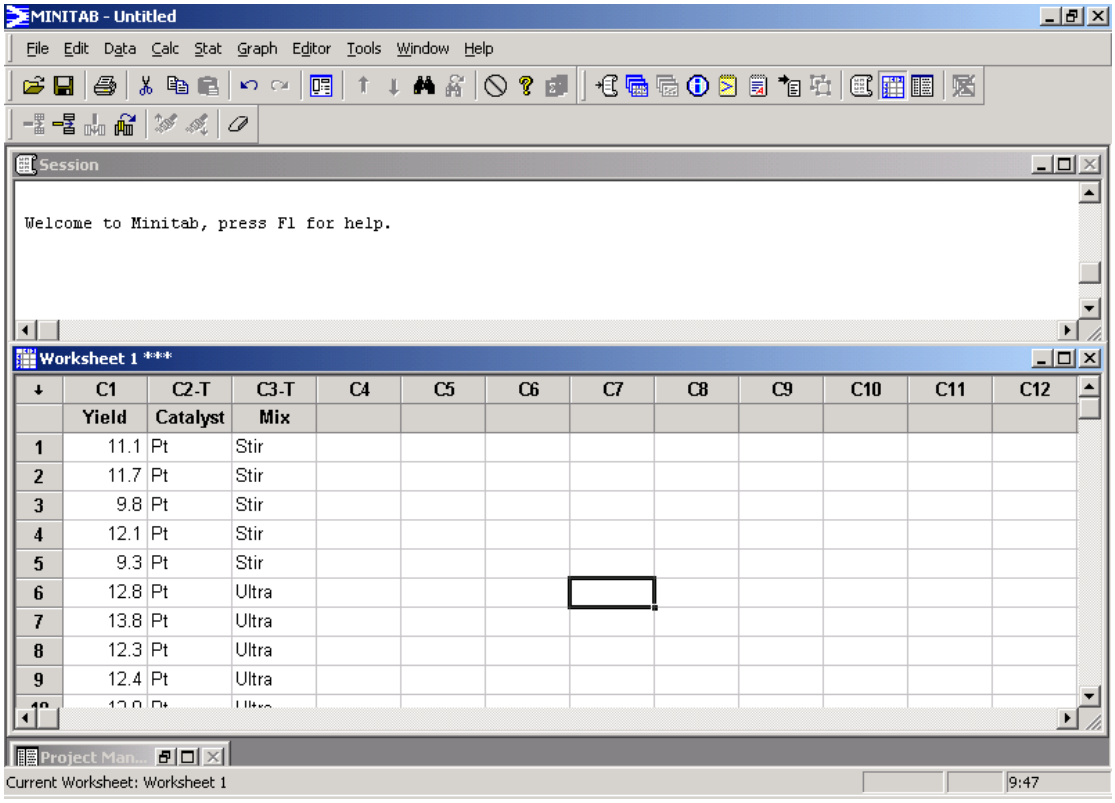
Example: Table 13.7 Effects of catalyst and mixing method on yield (Percentage of theoretical maximum)

Label one column to hold the yields ('Yield') and two others for labels for the two factors ('Catalyst' and 'Mixing').

Enter all the percentage yields into the relevant column and put suitable labels into the other two columns. The worksheet should then look like this:



	C1	C2-T	C3-T	C4	C5	C6	C7	C8	C9	C10	C11	C12
	Yield	Catalyst	Mix									
1	11.1	Pt	Stir									
2	11.7	Pt	Stir									
3	9.8	Pt	Stir									
4	12.1	Pt	Stir									
5	9.3	Pt	Stir									
6	12.8	Pt	Ultra									
7	13.8	Pt	Ultra									
8	12.3	Pt	Ultra									
9	12.4	Pt	Ultra									

Follow the menus:

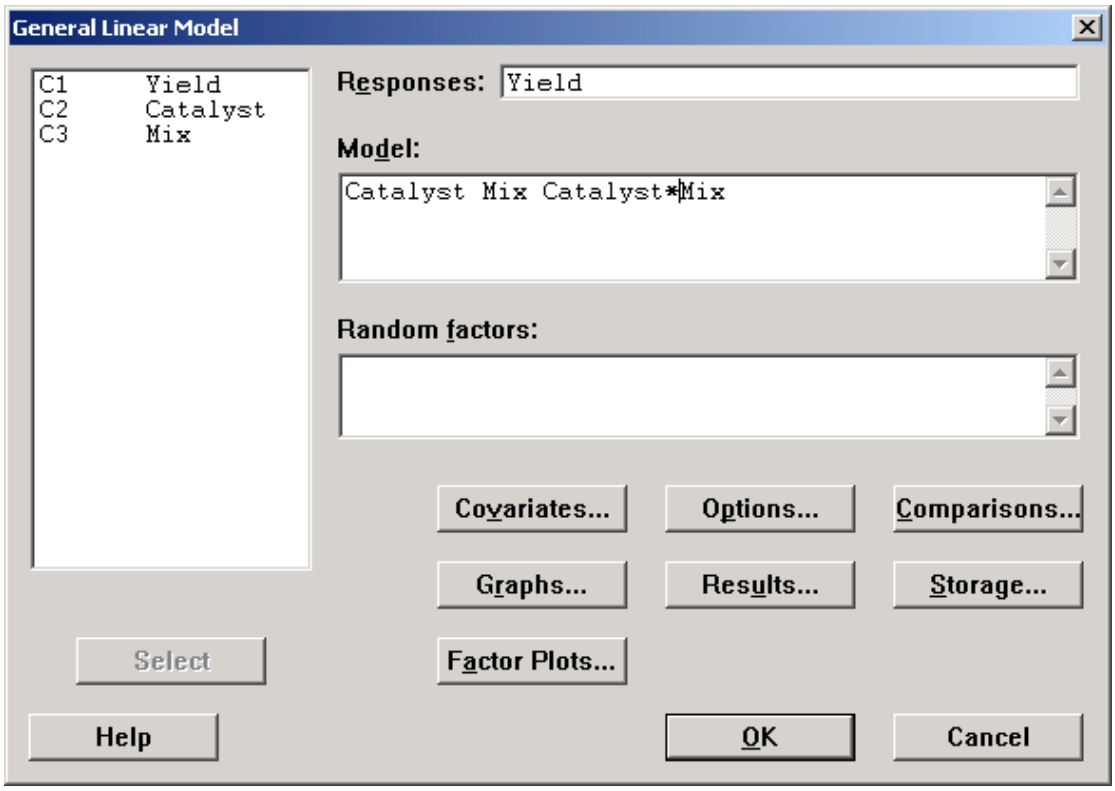
Stat / ANOVA / General Linear Model…

Technically, the General Linear Model (GLM) routine uses a method of calculation that is different from the classical two way ANOVA, but the end result is exactly the same. We choose GLM because its implementation in Minitab includes follow up tests like Tukey's, whereas the more obvious ANOVAs that are available from the menu, lack such facilities. Also, the GLM routine is tolerant of imbalanced data sets, so if for example, a lab accident led to the loss of one of the samples, we could still go ahead with a GLM analysis, but not with any of the traditional ANOVAs. (See Section 13.3.6)

In the Responses: box enter 'Yield', and for Model: enter:

‘Catalyst Mix Catalyst*Mix’

There are three terms. ‘Catalyst’ and ‘Mix’ are the two factors and ‘Catalyst*Mix’ is the interaction term. Notice that there are spaces between the three terms but no spaces within the interaction term. The GLM box should then be as below:



The output will be as on next page:

General Linear Model: Yield versus Catalyst, Mix

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Factor    Type   Levels  Values
Catalyst  fixed       5  Ir, Pd, Pd/Ir, Pt, Rh
Mix       fixed       2  Stir, Ultra

Analysis of Variance for Yield, using Adjusted SS for Tests

Source         DF   Seq SS   Adj SS  Adj MS      F      P
Catalyst        4  300.931  300.931  75.233  67.41  0.000
Mix             1   63.845   63.845  63.845  57.20  0.000
Catalyst*Mix    4    1.186    1.186   0.297   0.27  0.898
Error          40   44.644   44.644   1.116
Total          49  410.606

S = 1.05646   R-Sq = 89.13%   R-Sq(adj) = 86.68%

Unusual Observations for Yield

Obs    Yield      Fit  SE Fit  Residual  St Resid
 27  11.9000  14.3000  0.4725   -2.4000     -2.54 R
```

The key points are the P values in the last column of the section marked 'Analysis of Variance' (Yellow background). There are significant differences among the catalysts and among the mixing methods (P reported as 0.000 in both cases). As there is no evidence of interaction (P = 0.898), we can interpret the results for the main factors in a fairly simple manner (See Chapter 13).

The last line reports any unusual values. This is reported in terms of 'Standardised residuals' (SRs). If any point varies by more than (about) three SRs, it's a bad outlier. With such values, it always an idea to check that they are not data entry errors! In this case, Line 27 in the Minitab Worksheet contains a result for Iridium with Ultrasonication and the result is rather lower than the other replicates, but at –2.54 SRs, not a cause for panic.