SYSTAT: AN OVERVIEW

T. Krishnan
Cranes Software International Limited, Mahatma Gandhi Road, Bangalore - 560 001
krishnan.t@systat.com

1. Introduction

SYSTAT was designed for statistical analysis and graphical presentation of scientific and engineering data. In order to use this tutorial, knowledge of Windows 95/98/2000/Nt/XP would be helpful.

SYSTAT provides a powerful statistical and graphical analysis system in a new graphical user interface environment using descriptive menus, toolbars and dialog boxes. It offers numerous statistical features from simple descriptive statistics to highly sophisticated statistical algorithms.

Taking advantage of the enhanced user interface and environment, SYSTAT offers many major performance enhancements for speed and increased ease of use. Simply pointing and clicking the mouse can accomplish most tasks. SYSTAT provides extensive use of drag-n-drop and right click mouse functionality. SYSTAT's intuitive Windows interface and flexible command language are designed to make your research more efficient. You can quickly locate advanced options through clear, comprehensive dialogs.

SYSTAT also offers a huge data worksheet for powerful data handling. SYSTAT handles most of the popular data formats Excel, SPSS, SAS, BMDP, MINITAB, S-Plus, Statistica, Stata, JMP, and ASCII. All matrix operations and computations are menu driven.

The Graphics module of SYSTAT 12 is an enhanced version of the existing graphics module of SYSTAT 11. This module has better user interactivity to work with all graphical outputs of the SYSTAT application. Users can easily create 2D and 3D graphs using the appropriate top tool bar icons, which provide tool tip descriptions of graphs. Graphs could be created from the Graph top tool bar menu or by using the Graph Gallery, which facilitate accomplishing complex graphs (e.g. global map with contour, 3D surface plots with contour projections, etc.) with point and click of a mouse. Simply double clicking the graph will bring up a dialog to facilitate editing most of graph attributes from one comprehensive 'dynamic dialogue'. Each graph attribute such as line thickness, scale, symbols choice, etc. can be changed with mouse clicks. Thus simple or complex changes to a graph or set of graphs can be made quickly and done exactly as the user requires.

2. Getting Started With SYSTAT

2.1 Opening SYSTAT for Windows

To start SYSTAT for Windows NT4, 98, 2000, ME and XP:

- Choose: Start → All Programs→ SYSTAT 12→ SYSTAT 12

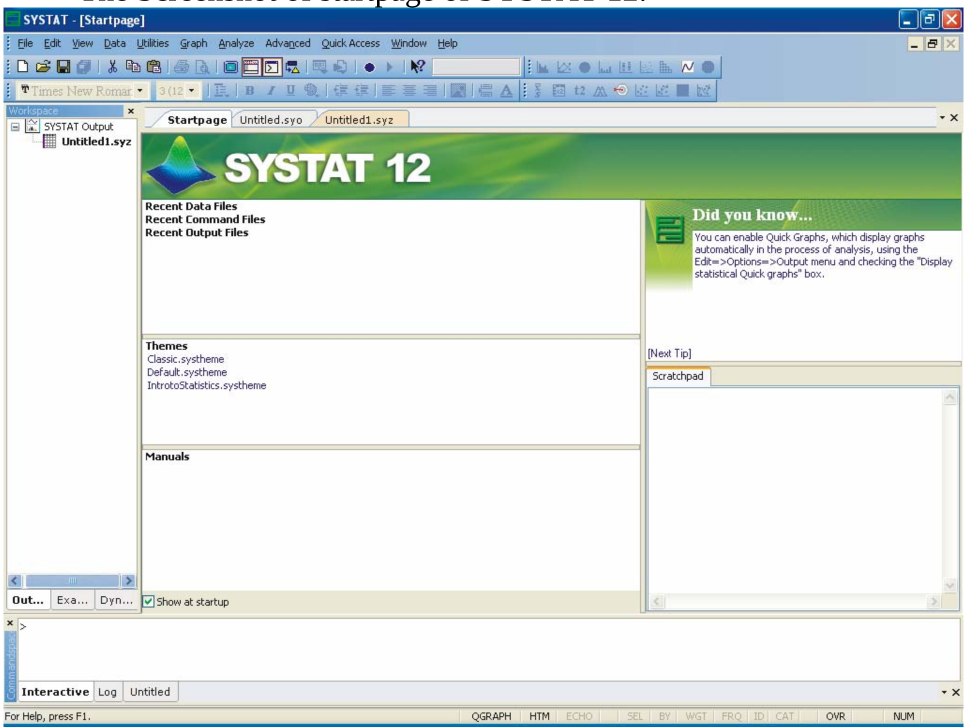
Alternatively, you can double-click on the SYSTAT icon , to get started with SYSTAT.

2.2 User Interface

The user interface of SYSTAT is organized into three spaces:

I. Viewspace
II. Workspace
III. Commandspace

The Screenshot of startpage of SYSTAT 12:



I. Viewspace has the following tabs

Output Editor: Graphs and statistical results appear in the Output Editor. You can edit, print and save the output displayed in the Output Editor.

Data Editor: The Data Editor displays the data in a row-by-column format. Each row is a case and each column is a variable. You can enter, edit, view, and save data in the Data Editor.

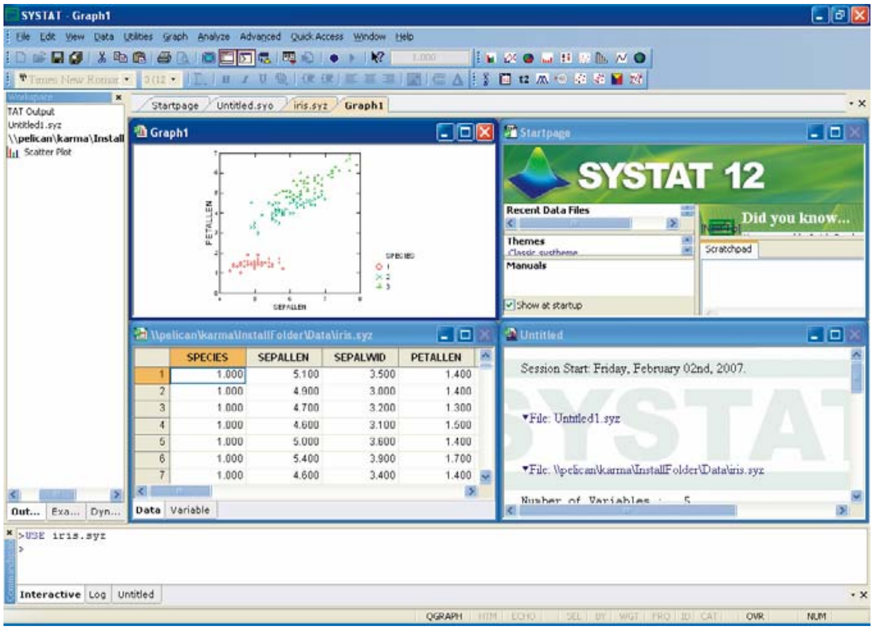
Graph Editor: You can edit and save graphs in the Graph Editor.

Startpage: Startpage window appears in Viewspace as you open SYSTAT. It has five sub-windows.

i. Recent Files
ii. Tips
iii. Themes
iv. Manuals
v. Scratchpad

You can resize the partition of the Startpage or you can close the startpage for the remainder of the session.

If you want to view the Data Editor and the Graph editor simultaneously click **Window** menu or right-click in the toolbar area and select **Tile** or **Tile vertically.**



II. Workspace has the following tabs

Output Organizer: The Output Organizer tab helps primarily to navigate through the results of your statistical analysis. You can quickly navigate to specific portions of output without having to use the Output Editor scrollbars.

Examples: The Examples tab enables you to run the examples given in the user manual with just a click of mouse. The SYSTAT examples tree consists of folders corresponding to different volumes of user manual and nodes. You can also add your own example.

Dynamic Explorer: The Dynamic Explorer can be used to rotate 3-D graphs, apply power transformations to values on one or more axes, and change the confidence intervals, ellipses, and kernels in scatter plots.

By default, the Dynamic Explorer appears automatically when the Graph Editor tab is active.

III. Commandspace has the following tabs

Interactive: In the Interactive tab, you can enter commands at the command prompt (>) and issue them by pressing the Enter key.

Untitled: The Untitled tab enables you to run the commands in the batch mode. You can open, edit, submit and save SYSTAT command file (.syc or .cmd)

Log: In the Log tab, you can view the record of the commands issued during the SYSTAT session (through Dialog or in the Interactive mode).

By default the tabs of Commandspace are arranged in the following order.

- Interactive
- Log
- Untitled

You can cycle through the three tabs using the following keyboard shortcuts:
- **CTRL+ALT+TAB.** Shifts focus one tab to the right.
- **CTRL+ALT+SHIFT+TAB.** Shifts focus one tab to the left.

SYSTAT Data, Command and Output files

Data files. You can save data files with (**.SYZ**) extension.

Command files. A command file is a text file that contains SYSTAT commands. Saving your analyses in a command file allows you to repeat them at a later date. These files are saved with **(.SYC)** extension.

Output files. SYSTAT displays statistical and graphical output in the output Editor. You can save the output in (.**SYO**), Rich Text format (.**RTF**) and HyperText Markup Language format (*.**HTM**).

The Data Editor

The Data Editor is used for entering, editing, and saving data. Entering data is a straightforward process. Editing data includes changing variable names or attributes, adding and deleting cases or variables, moving variables or cases, and correcting data errors.
SYSTAT imports and exports data in all popular formats, including Excel, ASCII Text, Lotus, BMDP Data, SPSS, SAS, StatView, Stata, Statistica, JMP, Minitab and S-Plus as well as from any ODBC compliant application.

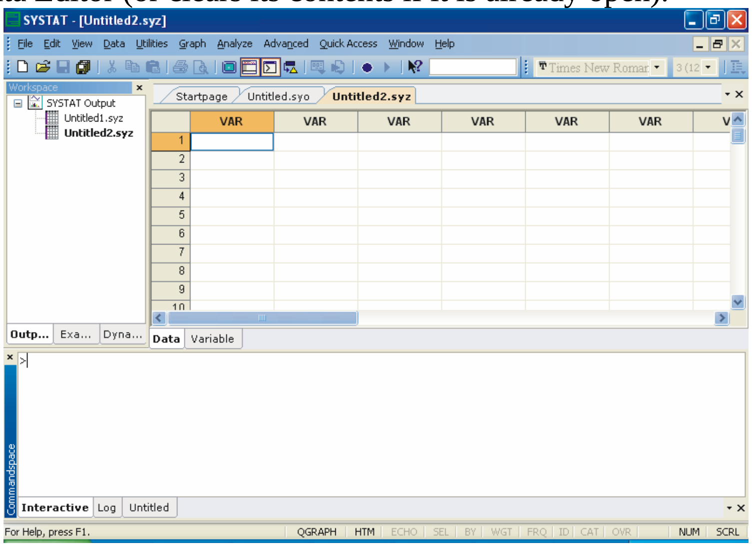
Data can be entered or imported in SYSTAT in the following way:

- **Entering data**

Consider the following data that has records about seven dinners from the frozen-food section of a grocery store.

Brand$	**Calories**	**Fat**
Lean Cuisine	240	5
Weight Watchers	220	6
Healthy Choice	250	3
Stouffer	370	19
Gourmet	440	26
Tyson	330	14
Swanson	300	12

To enter these data into Data Editor, from the menus choose: File→ **New→ Data**
This opens the Data Editor (or clears its contents if it is already open).

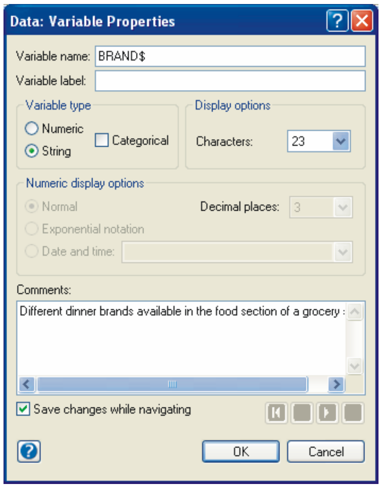


Before entering the values of variables you may want to set the properties of these variables using Variable Properties Dialog Box.
To open Variable Properties Dialog Box form the menus choose:

Data

Variable Properties …

Or right click (VAR) in the data editor and select **Variable Properties.** Or you can use **CTRL+SHIFT+P.**



Type *BRAND$* for the name. The dollar sign ($) at the end of the variable name indicates that the variable is a "string" or a "character" variable, as opposed to numeric variable.

Note: Variable names can have up to 256 characters.

- Select String as the Variable type.
- Enter the number of characters in the "Characters" box.
- In the Comments box you can give any comment or description of the variable if you want.

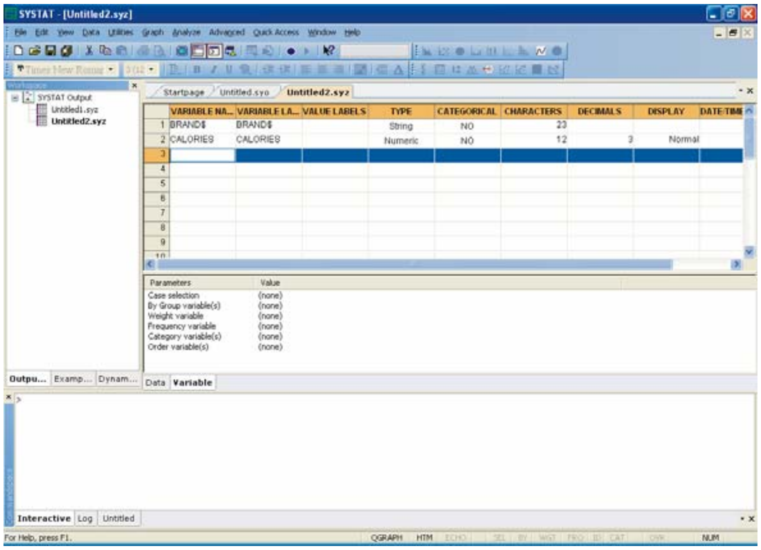
As here the variable *BRAND$* is explained.

- Click OK to complete the variable definition for VAR_1.

To type *CALORIES* as Variable name, again open the dialog box in the same way.

- Select Numeric as the Variable type.
- Enter the number of characters in the "Characters" box. [The decimal point is considered as a character.]
- Select the number of Decimal places to display.
- Click OK to complete the variable definition for VAR_2.
- Repeat this process for the *FAT* variable, selecting Numeric as the variable type or you can do the same in another way.

Double-click (VAR) or click the Variable tab in data editor to get Variable Editor. With Variable Editor you can edit variables directly.



You can specify the properties of *FAT* variable in the same way in the third row. Now after setting the variable properties you can start entering data by clicking the **Data** tab in Data Editor.

- Click the top left data cell (under the name of the first variable) and enter the data.
- To move across rows, press Enter or Tab after each entry. To move down columns, press the down arrow key.

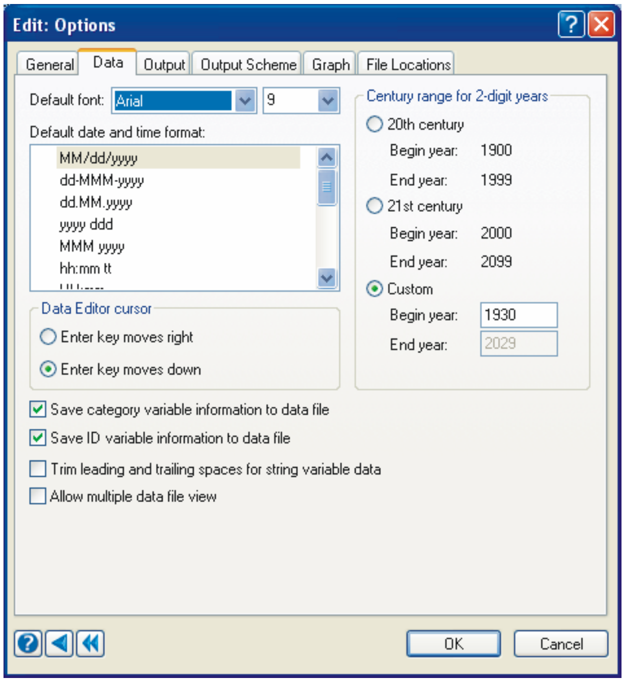
Note: To navigate the behavior of the **Enter key** in the Data Editor.

From the menus choose:

Edit

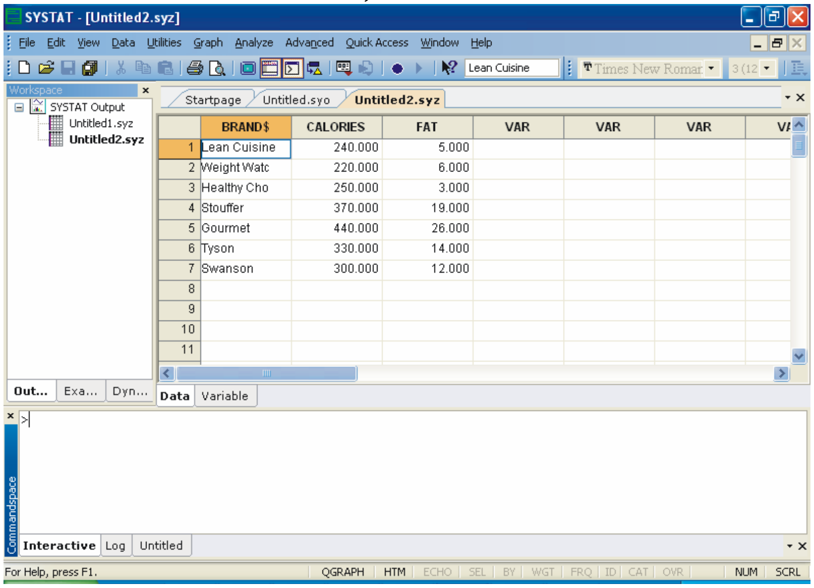
Options

Data…



- Click either of the two radio buttons below **Data Editor cursor.**

Once the data are entered in the Data Editor, the data file should look something like this:



For saving the data, from the menus choose:

File

  Save As…

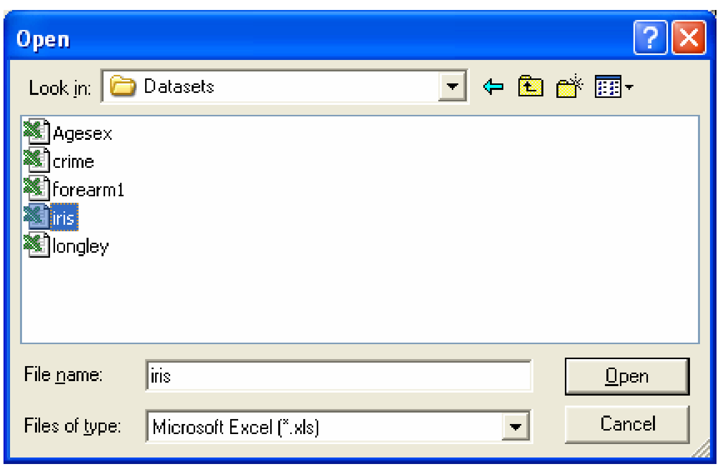
- **Importing Data.**

To import IRIS.xls. (data of Excel format) from the menus choose:

File

  Open

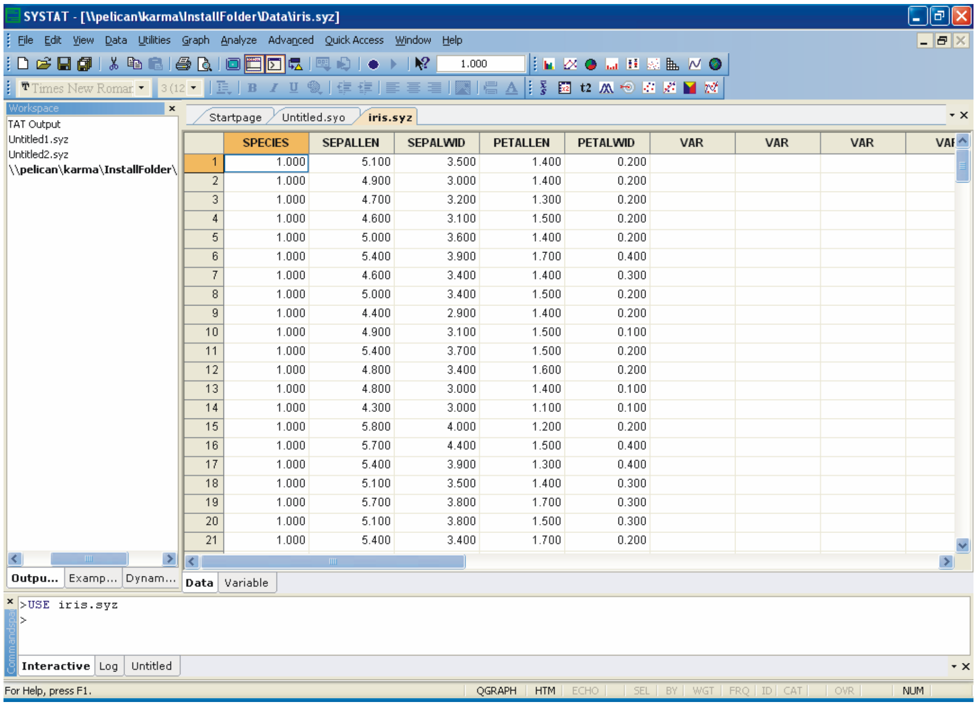
    Data...



From the ‘Files of type’ drop-down list, choose **Microsoft Excel**.

- Select the IRIS.xls file.
- Select the desired Excel sheet and click OK.

The data file in the Data Editor should look something like this:



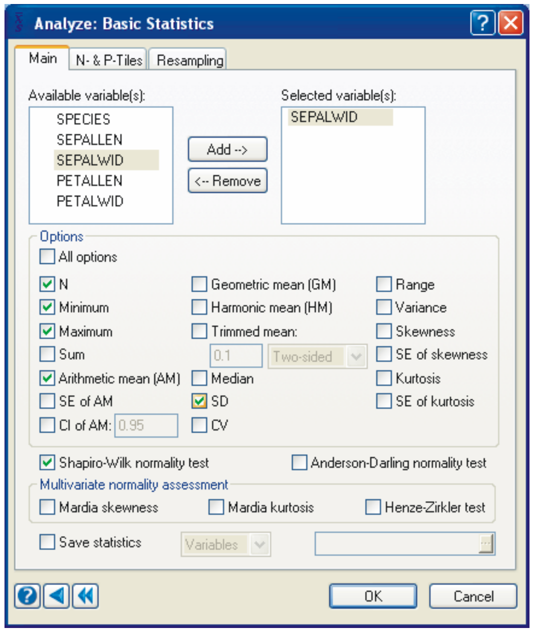
3. Statistical Analyses through SYSTAT

Descriptive Statistics

Descriptive Statistics offers basic statistics and stem-and-leaf plot for columns as well as rows. The basic statistics are: number of observations (N), minimum, maximum, mean, sum, trimmed mean, geometric mean, harmonic mean, standard deviation, variance, coefficient of variation (CV), range, median, standard error of mean, etc. Besides the above options, you can perform the Shapiro-Wilk test for normality. If you have chosen more than one variable, you can also compute multivariate statistics like multivariate skewness and multivariate kurtosis, and carry out the Henze-Zirkler multivariate normality test.

Example: We will use the IRIS data to compute descriptive statistics. This data set consists of four measurements made on 50 random samples of Iris flowers from each of the three species of Setosa, Versicolor, and Virginica (coded as 1, 2, and 3, respectively). The four measurements are *Sepal length*, *Sepal width*, *Petal length*, and *Petal width* in cm.
This is a famous data set from Fisher (1936).

To calculate basic statistics for the iris data, from the menu choose:
Analyze
Basic Statistics…



- Choose SEPALWID and add it to the Selected variable(s) list.
- Select N, Mean, SD, Minimum, Maximum.
- To check for normality, select the Shapiro-Wilk normality test option.
- Click OK.

The following output is displayed in the Output Editor:

```
                        SEPALWID
N of cases                  150
Minimum                   2.000
Maximum                   4.400
Mean                      3.057
Standard Dev              0.436
SW Statistic              0.985
SW P-Value                0.101
```

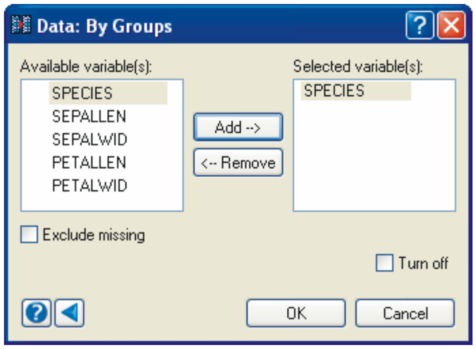
Correlation

The 'Correlation' feature computes correlations and measures of similarity and distance.
Example: In the previous example, we computed basic statistics for SEPALWID. We will now compute the correlations between the four variables.

Often, we may want to compute certain statistics separately for each group defined by certain variable(s) in the data set. In this case, we may want to examine if the correlations are of the same magnitude in the three species. SYSTAT facilitates such computations by its 'By Groups' feature. Let us use By Groups in the Data menu to request separate results for each level of *SPECIES* (grouping variables).

- From the menus choose:
- Data

  By Groups



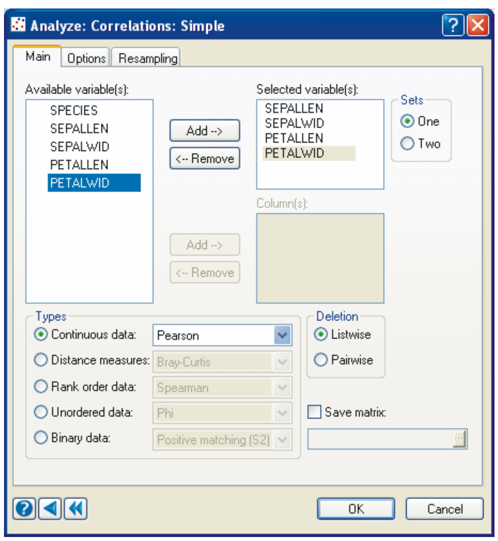
- In the By Groups dialog box, select *SPECIES* as variable.
- Click OK.
- Return to the Simple Correlations dialog box.
- Select all the four variables and add it to the Selected variable(s) list.
- Click OK.

To compute correlations between pairs of the four variables: *SEPALLEN*, *SEPALWID* *PETALLEN* and *PETALWID*, from the menus choose:

Analyze

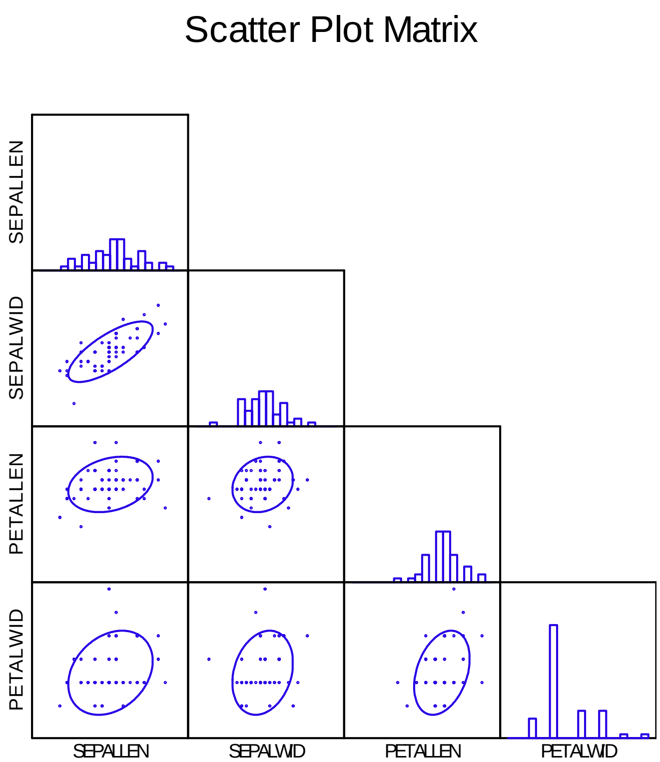
Correlations

Simple...



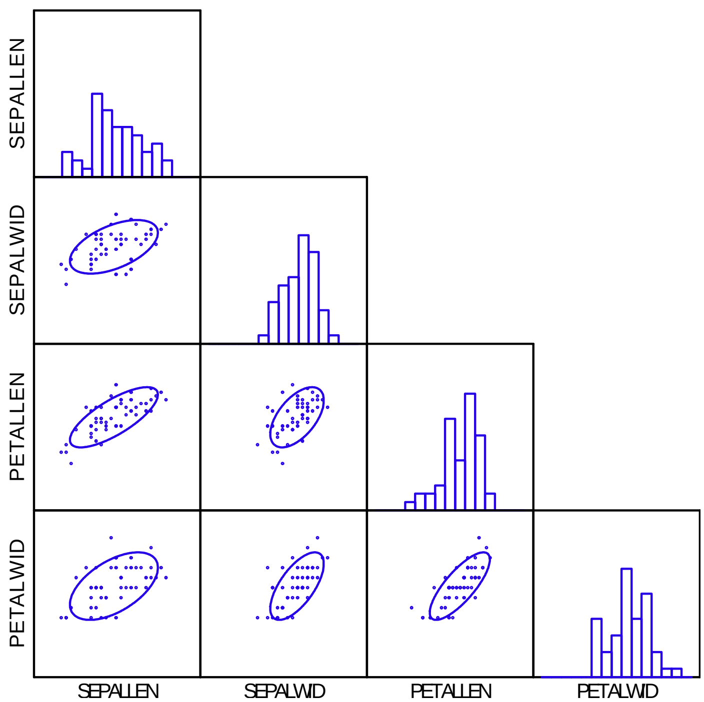
The following output is displayed in the Output Editor:

```
Results for SPECIES = 1.000
Number of Observations: 50
Means
SEPALLEN    SEPALWID    PETALLEN    PETALWID
----------------------------------------
   5.006       3.428       1.462       0.246

Pearson Correlation Matrix
         ¦ SEPALLEN    SEPALWID    PETALLEN    PETALWID
---------+----------------------------------------
SEPALLEN ¦    1.000
SEPALWID ¦    0.743       1.000
PETALLEN ¦    0.267       0.178       1.000
PETALWID ¦    0.278       0.233       0.332       1.000
```



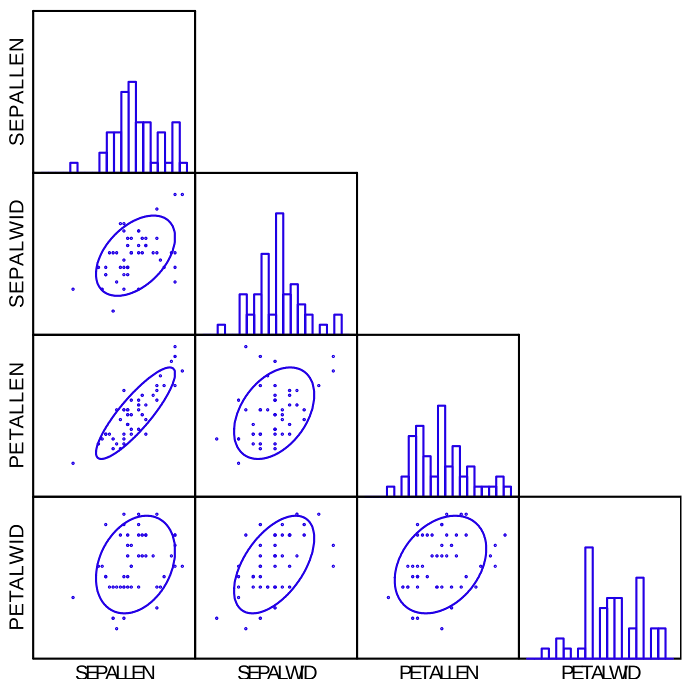
```
Results for SPECIES = 2.000
Number of Observations: 50
Means
SEPALLEN   SEPALWID   PETALLEN   PETALWID
---------------------------------------
   5.936      2.770      4.260      1.326

Pearson Correlation Matrix
         ¦ SEPALLEN   SEPALWID   PETALLEN   PETALWID
---------+--------------------------------------
SEPALLEN ¦    1.000
SEPALWID ¦    0.526      1.000
PETALLEN ¦    0.754      0.561      1.000
PETALWID ¦    0.546      0.664      0.787      1.000
```

Scatter Plot Matrix



```
Number of observations: 50
Results for SPECIES = 3.000
Number of Observations: 50
Means
SEPALLEN    SEPALWID    PETALLEN    PETALWID
-----------------------------------------
   6.588       2.974       5.552       2.026

Pearson Correlation Matrix
         ¦ SEPALLEN    SEPALWID    PETALLEN    PETALWID
---------+-----------------------------------------
SEPALLEN ¦    1.000
SEPALWID ¦    0.457       1.000
PETALLEN ¦    0.864       0.401       1.000
PETALWID ¦    0.281       0.538       0.322       1.000
```

Scatter Plot Matrix



Quick Graphs. ***Quick Graphs are graphs which are produced along with numeric output without the user invoking the Graph menu. A number of SYSTAT procedures include Quick Graphs.*** The Quick Graphs above are automatically generated when you request correlations (with the Quick Graphs options on). If you want to turn off the Quick Graph facility:

♦ Under **Edit** menu**,** click **Options.**

In the **Global Options** dialog, select the **Output** tab**.**

♦Turn off the **Display statistical Quick Graphs** option**.**

Or you can turn off the Quick Graph facility using the **QGRAPH** tab in the status bar at the bottom of user interface.

The above Quick Graphs in this example are in the scatterplot matrix (SPLOM). In each SPLOM there is one bivariate scatterplot corresponding to each entry in the correlation matrix that follows. A univariate histogram for each variable is displayed along the diagonal, and 75% normal distribution-based confidence ellipses are displayed within each plot. For species 3 (i.e., Virginica), the plot of *SEPALLEN* and *PETALLEN* has the narrowest ellipse, and thus, the strongest correlation, which is 0.864.

Hypothesis Testing

SYSTAT provides several parametric tests of hypotheses and confidence intervals for means, variances, proportions, and correlations. This section provides examples of the one-sample t-test and the paired t test.

One-Sample t-test

The one-sample t test is used to test if the mean of the population (from which the data set form a sample) is equal to a hypothesized value.

Example: One-Sample test. Let us study the effect of cigarette smoking on the carbon monoxide diffusing capacity (DL) of the lung. Ronald Knudson, Walter Klatenborn, and Benjamin Burrows found that current smokers had DL readings significantly lower than those of exsmokers or nonsmokers. Let us find out if the data indicate that the mean DL (μ) reading for current smokers is significantly lower than 100 DL.

The null hypothesis is H_o: $\mu = 100$ against the alternative hypothesis H_1: $\mu < 100$

The carbon monoxide diffusing capacities for a random sample of n=20 are entered in the Data Editor.

	DL_READING	VAR	VAR	VAR
1	103.768			
2	88.602			
3	73.003			
4	123.086			
5	91.052			
6	92.295			
7	61.675			
8	90.677			
9	84.023			
10	76.014			
11	100.615			
12	88.017			
13	71.210			
14	82.115			
15	89.222			
16	102.754			
17	108.579			
18	73.154			
19	106.755			
20	90.479			
21				
22				
23				

Data Variable

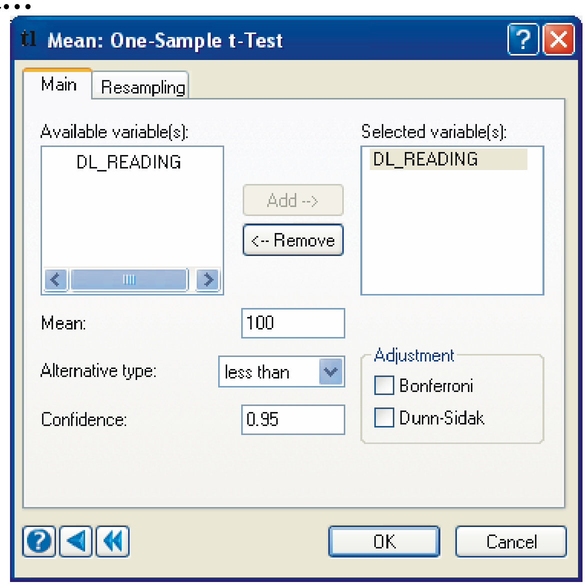
To perform one-sample t-test, from the menus choose:

Analyze

Hypothesis testing

Mean

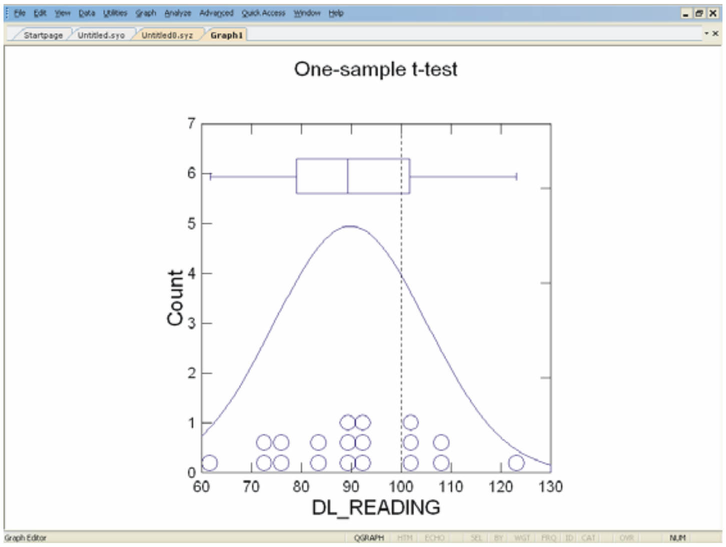
One-Sample t-test…



- Add DL_Reading to the Selected variable(s) list.
- Enter Mean 100.
- From the drop-down list, select the alternative type as 'less than'.
- Click OK.

The following output is displayed:

```
One-sample t-test of DL_READING with 20 Cases
Ho: Mean = 100.00 vs Alternative = 'less than'

Mean                     : 89.855
95.00% Confidence Bound : 95.617
Standard Deviation       : 14.904
t                        : -3.044
df                       :     19
p-value                  :  0.003
```

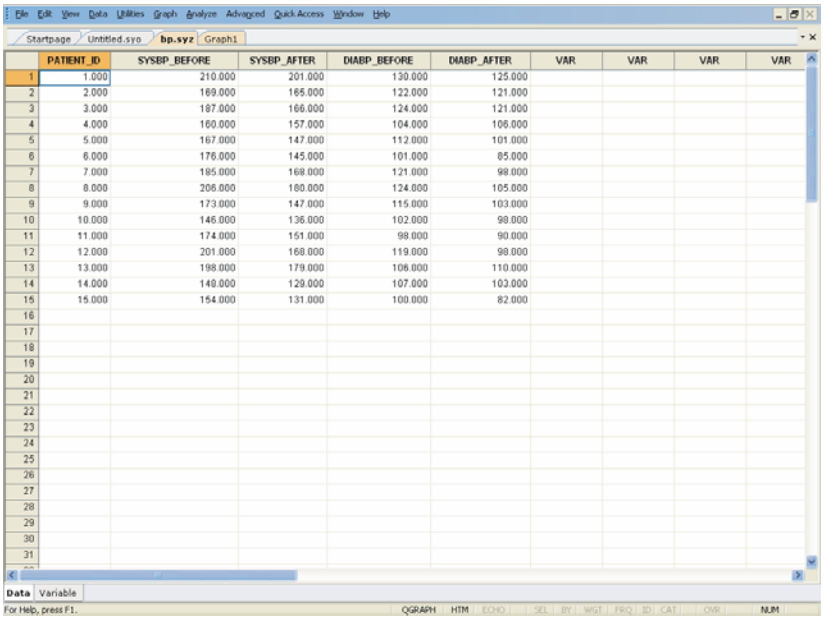


Conclusion: We observe that the one-sided p-value is 0.003, which is highly significant. Clearly, the mean DL (μ) reading for current smokers is significantly lower than 100 DL.

Paired t-test

The paired t-test assesses the equality of two means in experiments involving paired measurements.

Example: Paired t-test. To illustrate the paired t-test we use the data from Hand et al. (1996). The data were collected on the systolic blood pressure of 15 patients (MacGregor et al., 1979). The interest is to see if there is any difference in the systolic blood pressure of the patients, before and after the administration of a drug called captopril. The BP data file gives the supine systolic and diastolic blood pressures (mm Hg) for 15 patients with moderate essential hypertension, immediately before and two hours after administering the drug.



The null hypothesis is H_o: $\mu_d = 0$ (i.e. there is no difference in the systolic blood pressure of the patients, before and after the administration of the drug). The alternative hypothesis is H_1: $\mu_d > 0$ (i.e. there is positive difference in the systolic blood pressure of the patients, between before and after the administration of the drug, indicating that the drug has the desired effect.)

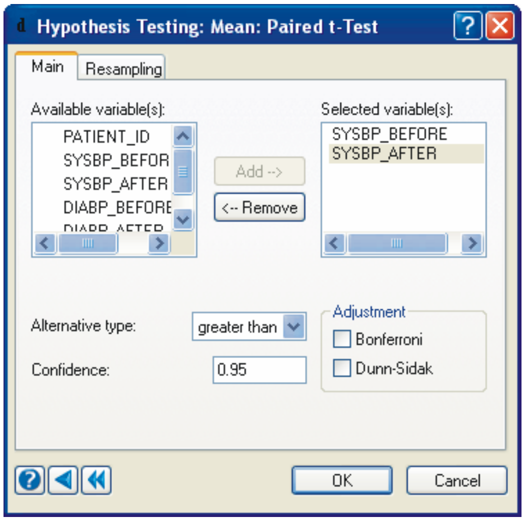
To perform paired t-test, from the menu choose:

Analyze

Hypothesis testing

Mean

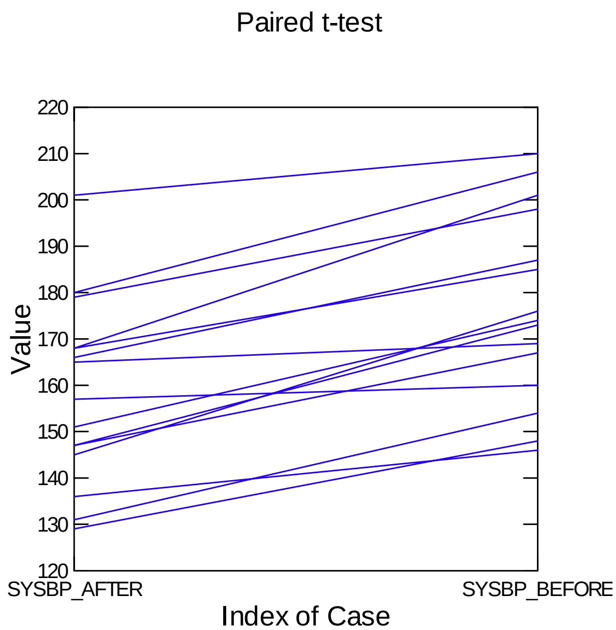
Paired t-test…



- Add SYSBP_BEFORE and SYSBP_AFTER in the Selected variable(s) list.
- From the drop-down list, select the alternative type as ‘greater than’.
- Click OK.

The output is displayed in the Output Editor.

```
Paired Samples t-test on SYSBP_BEFORE vs SYSBP_AFTER with 15 Cases
Alternative = 'greater than'

Mean SYSBP_BEFORE                  : 176.933
Mean SYSBP_AFTER                   : 158.000
Mean Difference                    :  18.933
95.00% Confidence Bound            :  14.828
Standard Deviation of Difference   :   9.027
t                                  :   8.123
df                                 :      14
p-value                            :   0.000
```



From the above graph, it is seen that the systolic blood pressure has decreased after the administration of the drug captopril. The test results (mean difference=18.933, p=0.000) indicate that the drug captopril reduces the systolic blood pressure.

You can do the same testing using the **Example** tab of Workspace as this is already included as an example in Hypothesis testing of Statistics-I. So for running this example using the Examples tree (which is collapsible) first click the example tab in Workspace then click

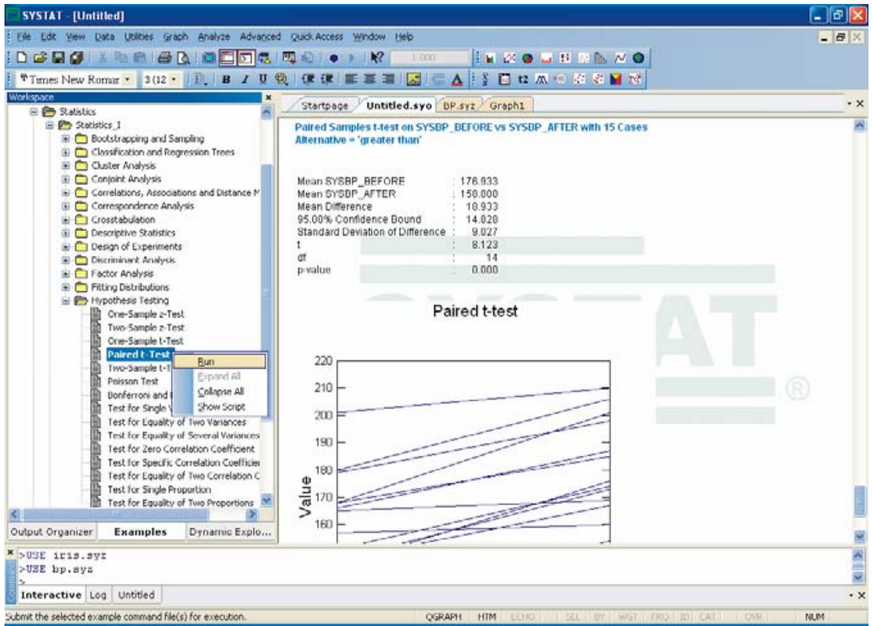
Statistics

Statistics_1

Hypothesis Testing

Paired t-Test…

Then you just double-click or right-click and select **Run**.

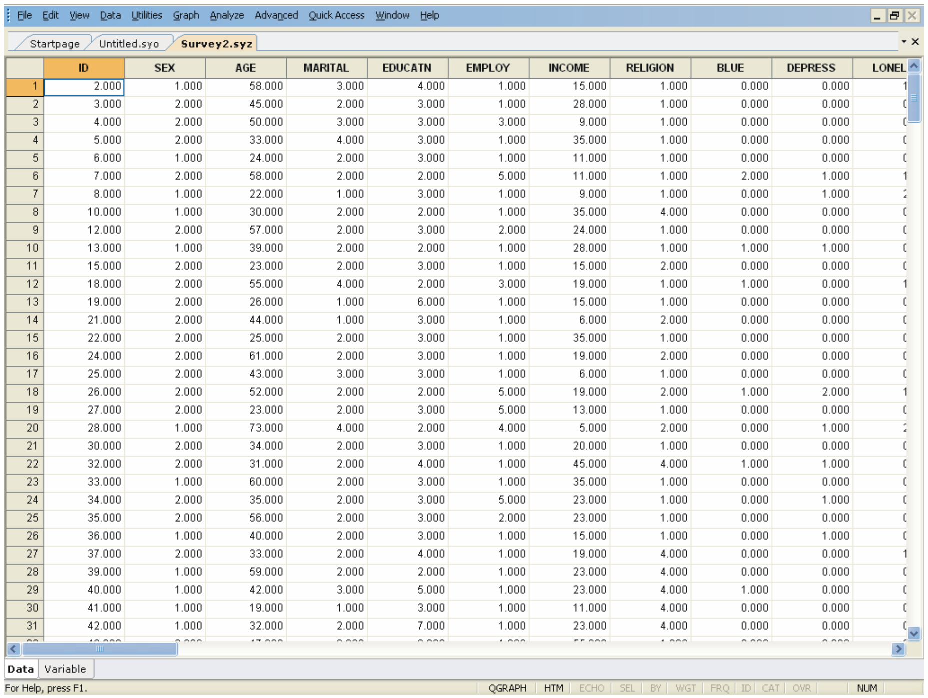


R × C Contingency Table

A contingency table provides a display of (joint) frequencies of categorical (or discrete) data to study relationships between two or more variables. Using Crosstabulation, you can analyze and save frequency tables that are formed by categorical variables.

Example: Contingency Table. This example uses questionnaire data from a community survey (Afifi et al., 2004). The survey was conducted to study depression and help-seeking behavior among adults. The CESD depression index was constructed by asking people to respond to 20 items. The *SURVEY2* data file includes a record (case) for each of the 256 subjects in the sample. The data set consists of following variables:

ID	SEX	AGE	MARITAL	EDUCATN	EMPLOY
INCOME	RELIGION	BLUE	DEPRESS	LONELY	CRY
SAD	FEARFUL	FAILURE	AS_GOOD	HOPEFUL	HAPPY
ENJOY	BOTHERED	NO_EAT	EFFORT	BADSLEEP	GETGOING
MIND	TALKLESS	UNFRNDLY	DISLIKE	TOTAL	CASECONT
DRINK	HEALTHY	DOCTOR	MEDS	BED_DAYS	ILLNESS
CHRONIC	MARITAL$	SEX$	AGE$	EDUC$	

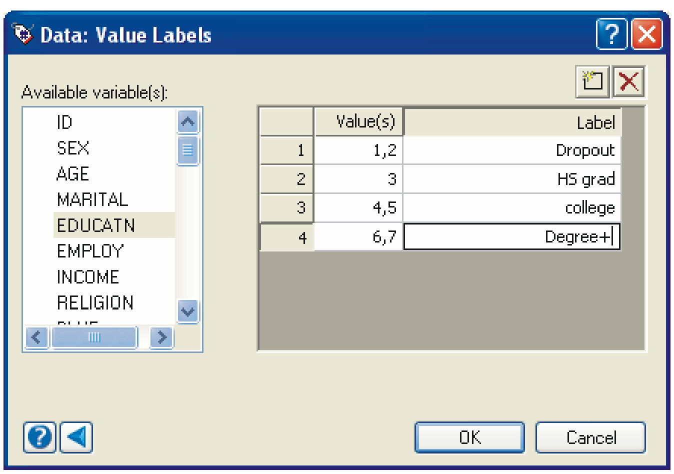


To study the relationship between depression and education, label the *EDUCATN* and *CASECONT* into categories using the Label dialog box.

To open the Label dialog box, from the menus choose:

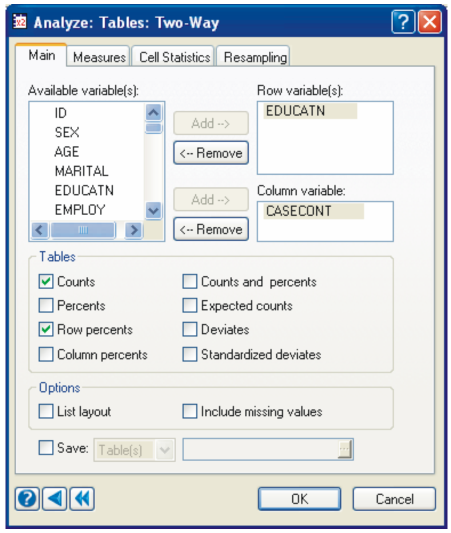
Data

Label…



- Select *EDUCATN* as the variable.
- Type the value(s) that require labels.
- Type the label for each specified value.
- Click OK.
- Repeat the process for the variable *CASECONT* and label the value ‘1’ as **depressed** and ‘0’ as **normal.**

To tabulate, from the menus choose:
Analyze
Tables
Two-Way…



- Select *EDUCATN* as the Row variable(s) and *CASECONT* as the Column variable.
- Below the **Tables**, check the Counts and the **Row percents** boxes.
- Click OK.

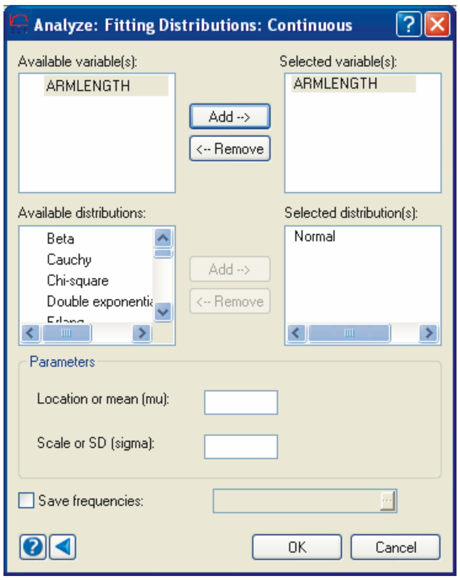
```
Counts
EDUCATN(rows) by CASECONT(columns)
         ¦ normal   depressed   Total
---------+---------------------------
Dropout  ¦      3           0       3
Dropout  ¦     33          14      47
HS grad  ¦     80          18      98
college  ¦     42           3      45
college  ¦     33           8      41
Degree+  ¦     14           0      14
Degree+  ¦      7           1       8
---------+---------------------------
Total    ¦    212          44     256

Row Percents

EDUCATN(rows) by CASECONT(columns)
         ¦  normal   depressed ¦   Total          N
---------+---------------------+-------------------
Dropout  ¦ 100.000       0.000 ¦ 100.000      3.000
Dropout  ¦  70.213      29.787 ¦ 100.000     47.000
HS grad  ¦  81.633      18.367 ¦ 100.000     98.000
college  ¦  93.333       6.667 ¦ 100.000     45.000
college  ¦  80.488      19.512 ¦ 100.000     41.000
Degree+  ¦ 100.000       0.000 ¦ 100.000     14.000
Degree+  ¦  87.500      12.500 ¦ 100.000      8.000
---------+---------------------+-------------------
Total    ¦  82.813      17.188 ¦ 100.000
N        ¦ 212.000      44.000 ¦            256.000
```

```
*** WARNING *** : More than One-fifth of the fitted Cells are sparse
(Frequency < 5).
Significance Tests computed on this table are Suspect.


Chi-square tests of association for EDUCATN and CASECONT

                   ¦
Test Statistic     ¦  Value      df   p-value
-------------------+------------------------
Pearson Chi-square ¦ 12.645   6.000     0.049


Number of Valid Cases: 256
```

Conclusion:
Subject to the reservation mentioned in the Warning message, we see that there is some association between Education and Depression state (p-value only just less than 0.05). The association is neither strong; nor is the direction of the association vis a vis Education is clear.

Fitting Distributions
The ‘Fitting Distributions’ feature enables you to assess whether the observed data can be modeled by a distribution from a parametric family of distributions with appropriately chosen parameter values.

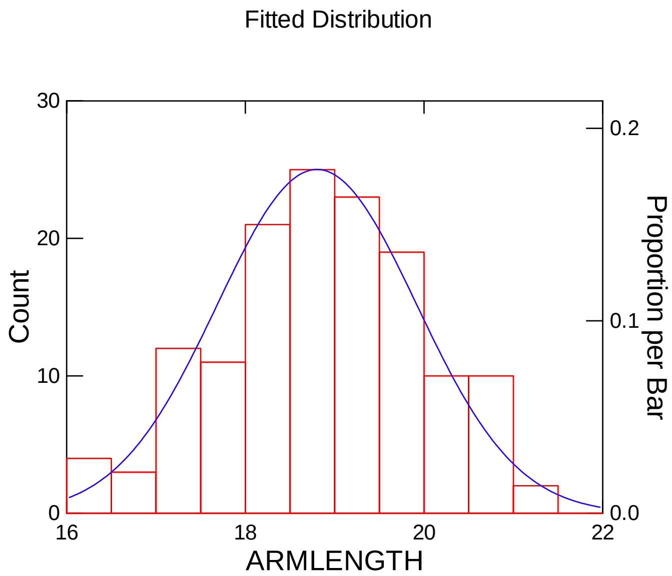
Example: Fitting of Normal Distribution. The data in **FOREARM1** contains length of forearm (in inches) from Pearson and Lee (1903). A normal distribution may be an appropriate model to describe the data on the forearm length.
To fit a normal distribution, from the menus choose:
Analyze
  Fitting Distributions
    Continuous…



- Add *ARMLENGTH* to the Selected variable(s) list.
- Select Distribution as **Normal.**
- Click OK.

The output is displayed in the Output Editor:

```
Variable Name : ARMLENGTH
Distribution  : Normal

Estimated Parameter(s)
Location or Mean(mu) : 18.802143
Scale or SD(sigma)   :  1.116466



Estimation of Parameter(s): Maximum Likelihood Method

Test Results
Lower Limit   Upper Limit   Observed     Expected
-------------------------------------------------
          .     17.160000         11     9.893397
  17.160000     17.690000         12    12.449753
  17.690000     18.220000         16    19.802248
  18.220000     18.750000         29    25.247070
  18.750000     19.280000         22    25.802405
  19.280000     19.810000         24    21.137956
  19.810000     20.340000         11    13.880695
  20.340000             .         15    11.786478
                                 140   140.000000

Chi-square Test Statistic : 3.849814
Degrees of Freedom        :        5
p-value                   : 0.571236

Kolmogorov-Smirnov Test Statistic : 0.047870
Lilliefors Probability            : 0.554270

Shapiro-Wilk Test Statistic  : 0.991759
p-value                      : 0.590263
```



Conclusion: The above analysis indicates that a normal distribution fits the data well.
In this case, we let SYSTAT estimate the parameters of the normal distribution. It is also possible to fit a normal distribution with parameters of your choice; in that case, you need to enter the values in the parameter edit boxes provided for them in the dialog box.

Analysis of Variance

We used the t-test for comparing the mean of one sample with a specified value or for comparing the means of two groups. In many situations there is a need to compare several means and to test the significance of differences between three or more means from independently sampled populations.

Example: One Way ANOVA. This example uses a one-way design to compare average typing speeds of three groups of typists. Fourteen beginning typists were randomly assigned to three types of machines and given speed tests. The following are their typing speeds in words per minute:

Electric	Word processor	Plain old
52	67	52
47	73	43
51	70	47
49	75	44
53	64	

Does the equipment influence typing performance?

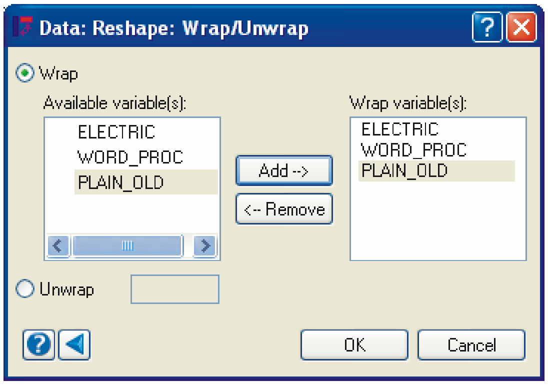
H_o: The average speeds of the three machines are the same.
H_1: The average speeds of the three machines are not all the same.

To carry out analysis of variance using the above data, we need to reorganize the data in a form suitable for SYSTAT. This is done by using the `Reshape' feature and `wrapping' the columns as follows. Wrapping puts the group variable in one column and the measurement variable in another column. Thus we need to wrap the data in two columns for which from the menus choose:

Data

Reshape

Wrap/Unwrap…..



The data file looks as follows:

	TRIAL	MEASURE	(VAR00003)
1	1.0000	52.0000	
2	2.0000	67.0000	
3	3.0000	52.0000	
4	1.0000	47.0000	
5	2.0000	73.0000	
6	3.0000	43.0000	
7	1.0000	51.0000	
8	2.0000	70.0000	
9	3.0000	47.0000	
10	1.0000	49.0000	
11	2.0000	75.0000	
12	3.0000	44.0000	
13	1.0000	53.0000	
14	2.0000	64.0000	
15	3.0000	.	
16			
17			
18			
19			

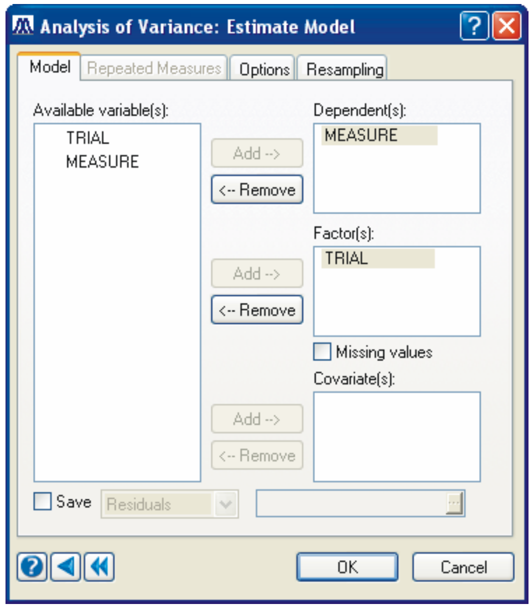
The variable *MEASURE* is the typing speed using three types of machines. The levels '1', '2' and '3' correspond to machines *ELECTRIC*, *WORD PROCESSOR* and *PLAIN OLD* respectively in the TRIAL column. Of course, you might like to rename `Trial' as `Equipment$' and `Measure' as `Speed' using the Variable Properties dialog.

Now let us do one-way analysis of variance using the wrapped data. To perform One-Way ANOVA, from the menus choose:

Analyze

Analysis of Variance

Estimate Model…

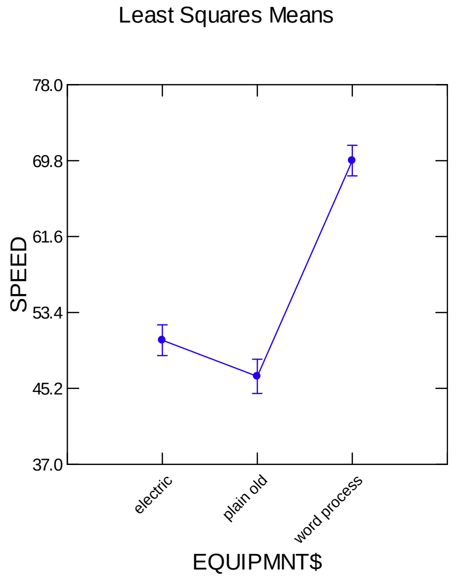


- Add *MEASURE* as the **Dependent** variable.
- Add *TRIAL* as the **Factor.**
- Click OK.

The output is displayed in the Output Editor:

```
Effects coding used for categorical variables in model.
The categorical values encountered during processing are


Variables        ¦             Levels
-----------------+-----------------------------
TRIAL (3 levels) ¦ 1.000000   2.000000   3.000000

1 case(s) are deleted due to missing data.

Dependent Variable ¦  MEASURE
N                  ¦       14
Multiple R         ¦ 0.952266
Squared Multiple R ¦ 0.906811

Analysis of Variance
Source ¦ Type III SS   df   Mean Squares     F-ratio    p-value
-------+--------------------------------------------------------
TRIAL  ¦ 1469.357143    2     734.678571   53.519631   0.000002
Error  ¦  151.000000   11      13.727273

Least Squares Means
Factor ¦ Level      LS Mean   Standard Error          N
-------+---------------------------------------------------
TRIAL  ¦ 1        50.400000         1.656941   5.000000
TRIAL  ¦ 2        69.800000         1.656941   5.000000
TRIAL  ¦ 3        46.500000         1.852517   4.000000
```

```
Durbin-Watson D Statistic   ¦  3.152318
First Order Autocorrelation ¦ -0.696026

Information Criteria
AIC             ¦ 81.025394
AIC (Corrected) ¦ 85.469838
Schwarz's BIC   ¦ 83.581623
```



Conclusion: We reject the hypothesis as the p-value is small. The Quick Graph illustrates this finding. Although the typists using electric and plain old typewriters have similar average speeds (50.4 and 46.5, respectively), the word processor group has a much higher average speed.

Example: Two Way ANOVA. Consider the following data from a two-factor (Drug & Disease) experiment, from Afifi and Azen (1972), cited in Neter et al. (1996). The dependent variable, *SYSINCR*, is the change in systolic blood pressure after administering one of four different drugs to patients with one of three different diseases. Patients were assigned randomly to one of the possible drugs. The data are stored in the SYSTAT file ***AFIFI***.

S.no	DRUG	DISEASE	SYSINCR	S.no	DRUG	DISEASE	SYSINCR
1	1	1	42	29	2	3	4
2	1	1	44	30	2	3	16
3	1	1	36	31	3	1	1
4	1	1	13	32	3	1	29
5	1	1	19	33	3	1	19
6	1	1	22	34	3	2	11
7	1	2	33	35	3	2	9
8	1	2	26	36	3	2	7
9	1	2	33	37	3	2	1
10	1	2	21	38	3	2	-6
11	1	3	31	39	3	3	21

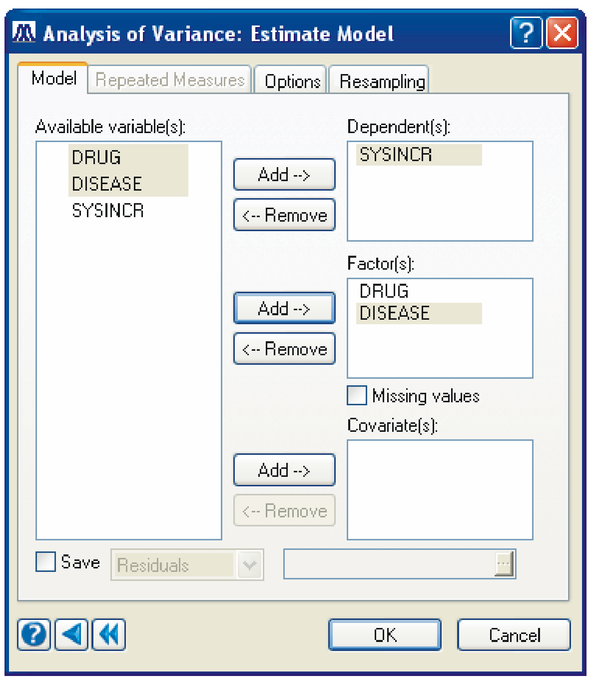
12	1	3	-3	40	3	3	1
13	1	3	25	41	3	3	9
14	1	3	25	42	3	3	3
15	1	3	24	43	4	1	24
16	2	1	28	44	4	1	9
17	2	1	23	45	4	1	22
18	2	1	34	46	4	1	-2
19	2	1	42	47	4	1	15
20	2	1	13	48	4	2	27
21	2	2	34	49	4	2	12
22	2	2	33	50	4	2	12
23	2	2	31	51	4	2	-5
24	2	2	36	52	4	2	16
25	2	3	3	53	4	2	15
26	2	3	26	54	4	3	22
27	2	3	28	55	4	3	7
28	2	3	32	56	4	3	25
				57	4	3	5
				58	4	3	12

To perform Two-way ANOVA, from the menus choose:

Analyze

Analysis of Variance

Estimate Model…



Select *SYSINCR* as the **Dependent** variable.

- Add *DRUG* and *DISEASE* in the **Factor** list box**.**
- Click OK.

Note: While performing ANOVA, all interaction terms are included in the analysis. If you want to specify your own model then use the ‘GLM’ feature.

The output is displayed in the Output Editor:

```
Effects coding used for categorical variables in model.
The categorical values encountered during processing are
Variables           ¦                    Levels
--------------------+---------------------------------------------
DRUG (4 levels)     ¦ 1.000000   2.000000   3.000000   4.000000
DISEASE (3 levels)  ¦ 1.000000   2.000000   3.000000

Dependent Variable  ¦  SYSINCR
N                   ¦       58
Multiple R          ¦ 0.675296
Squared Multiple R  ¦ 0.456024

Analysis of Variance
Source        ¦ Type III SS   df   Mean Squares    F-ratio    p-value
--------------+------------------------------------------------------
DRUG          ¦ 2997.471860    3     999.157287   9.046033   0.000081
DISEASE       ¦  415.873046    2     207.936523   1.882587   0.163736
DRUG*DISEASE  ¦  707.266259    6     117.877710   1.067225   0.395846
Error         ¦ 5080.816667   46     110.452536

Least Squares Means
Factor ¦ Level     LS Mean   Standard Error           N
-------+-------------------------------------------------
DRUG   ¦ 1       25.994444         2.751008   15.000000
DRUG   ¦ 2       26.555556         2.751008   15.000000
DRUG   ¦ 3        9.744444         3.100558   12.000000
DRUG   ¦ 4       13.544444         2.637123   16.000000

Least Squares Means
Factor  ¦ Level     LS Mean   Standard Error           N
--------+-------------------------------------------------
DISEASE ¦ 1       21.816667         2.492580   19.000000
DISEASE ¦ 2       19.745833         2.445986   19.000000
DISEASE ¦ 3       15.316667         2.374380   20.000000

Least Squares Means
Factor        ¦ Level     LS Mean   Standard Error          N
--------------+------------------------------------------------
DRUG*DISEASE ¦ 1*1     29.333333         4.290543   6.000000
DRUG*DISEASE ¦ 1*2     28.250000         5.254820   4.000000
DRUG*DISEASE ¦ 1*3     20.400000         4.700054   5.000000
DRUG*DISEASE ¦ 2*1     28.000000         4.700054   5.000000
DRUG*DISEASE ¦ 2*2     33.500000         5.254820   4.000000
DRUG*DISEASE ¦ 2*3     18.166667         4.290543   6.000000
DRUG*DISEASE ¦ 3*1     16.333333         6.067744   3.000000
DRUG*DISEASE ¦ 3*2      4.400000         4.700054   5.000000
DRUG*DISEASE ¦ 3*3      8.500000         5.254820   4.000000
DRUG*DISEASE ¦ 4*1     13.600000         4.700054   5.000000
DRUG*DISEASE ¦ 4*2     12.833333         4.290543   6.000000
DRUG*DISEASE ¦ 4*3     14.200000         4.700054   5.000000
Durbin-Watson D Statistic    ¦  2.413731
First Order Autocorrelation ¦ -0.223131
Information Criteria
AIC                ¦ 450.018358
AIC (Corrected)    ¦ 458.291085
Schwarz's BIC      ¦ 476.804117
```

Conclusion: In two-way ANOVA, begin the analysis by looking at the interaction effect. The *DRUG * DISEASE* interaction is not significant (p = 0.396), so shift your focus to the main effects.

The *DRUG* effect is significant (p < 0.0005), but the *DISEASE* effect is not (p = 0.164). Thus, at least one of the drugs differs from the others with respect to blood pressure change, but blood pressure change does not vary significantly across diseases.

Note: Along with ANOVA table, SYSTAT also displays the Estimates of the model parameters. To get the estimates, you need to select **LONG** as the PLENGTH option. To do so, from the menus, choose
- **Edit →Options.**
- **Select the Output tab.** From the **Output results**, select **Length** as **Long.**

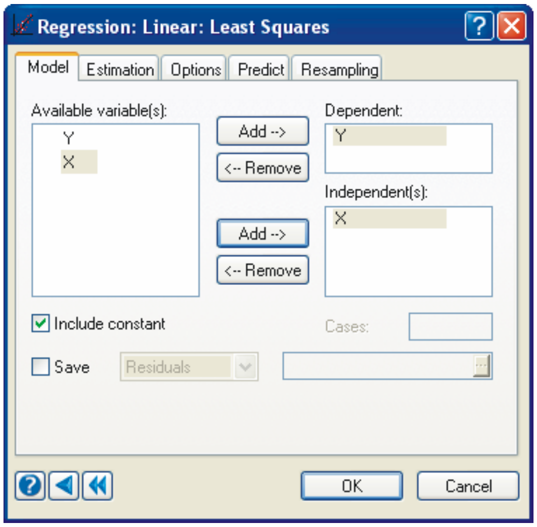
Linear Regression
Regression analysis is used to investigate a predictive relationship between a response variable and one or more predictors.

Example: Let us study the relationship between noise exposure (predictor or independent variable) and hypertension (dependent or response variable). The following data were collected on *Y* (blood pressure rise in millimeters of mercury) and *X* (sound pressure level in decibels).

Y	X
1	60
0	63
1	65
2	70
5	70
1	70
4	80
6	90
2	80
3	80
5	85
4	89
6	90
8	90
4	90
5	90
7	94
9	100
7	100
6	100

To perform Linear Regression, from the menus choose:

Analyze
Regression
Linear
Least Squares…



- Select *Y* as the **Dependent** variable.
- Select *X* as the **Independent** variable**.**
- Click OK.

The output is displayed in the Output Editor:

```
Eigenvalues of Unit Scaled X'X
       1          2
-------------------
1.989028   0.010972

Condition Indices
       1           2
--------------------
1.000000   13.463989

Variance Proportions
         ¦        1          2
---------+-------------------
CONSTANT ¦ 0.005486   0.994514
X        ¦ 0.005486   0.994514

Dependent Variable           ¦ Y
N                            ¦ 20
Multiple R                   ¦ 0.865019
Squared Multiple R           ¦ 0.748257
Adjusted Squared Multiple R  ¦ 0.734271
Standard Error of Estimate   ¦ 1.317963


Regression Coefficients B = (X'X)^{-1}X'Y
```

Effect	Coefficient	Standard Error	Std. Coefficient	Tolerance	t	p-value
CONSTANT	-10.131538	1.994900	0.000000	.	-5.078720	0.000078
X	0.174294	0.023829	0.865019	1.000000	7.314472	0.000001

Confidence Interval for Regression Coefficients

Effect	Coefficient	95.0% Confidence Interval Lower	Upper	VIF
CONSTANT	-10.131538	-14.322667	-5.940408	.
X	0.174294	0.124232	0.224356	1.000000

Analysis of Variance

Source	SS	df	Mean Squares	F-ratio	p-value
Regression	92.933525	1	92.933525	53.501505	0.000001
Residual	31.266475	18	1.737026		

```
*** WARNING *** :
Case 5 is an Outlier (Studentized Residual : 2.740993)
```

Durbin-Watson D Statistic	2.289856
First Order Autocorrelation	-0.179127

Information Criteria

AIC	71.693825
AIC (Corrected)	73.193825
Schwarz's BIC	74.681021

Conclusion. The estimates of the regression coefficients are -10.132 and 0.174, so the regression equation is:
Y= -10.132 +0.174**X**

F-ratio in the analysis of variance table is used to test the hypothesis that the slope is 0 (or, for multiple regressions, that all slopes are 0). The *F* is large when the independent variable(s) helps to explain the variation in the dependent variable. Here, there is a significant linear relation between *Y* and *X*. Thus, we reject the hypothesis that the slope of the regression line is zero (**F-ratio** = 53.502, *p* value (**P**) < 0.0005). SYSTAT also outputs statistics and warnings for outlier detection and for testing the assumptions in linear regression methodology.

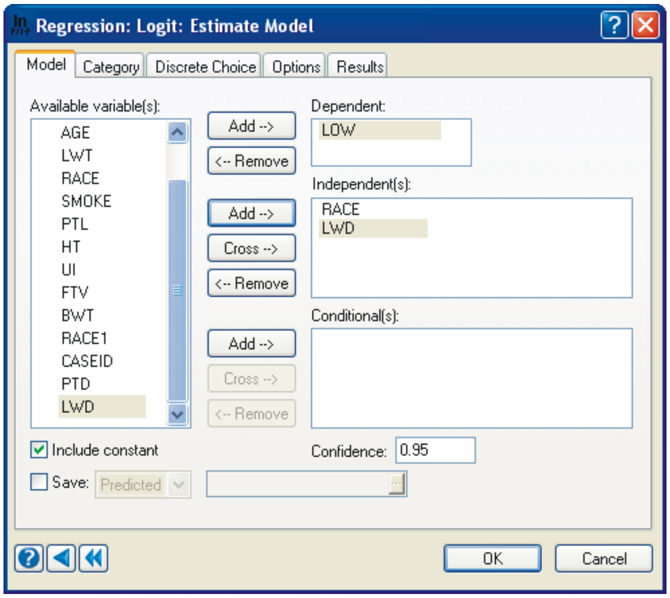
Logistic Regression

Logistic regression describes the relationship between a ***dichotomous*** response variable and a set of explanatory (predictor or independent) variables. The explanatory variables may be continuous or (dummy variables) discrete.

Example: Binary Logistic Regression. To illustrate the use of binary logistic regression, we consider this example from Hosmer and Lemeshow (2000). The purpose is to analyse low infant birth weight (LOW) as a function of several risk factors.

For the present analysis we are considering only mother's weight during last menstrual period (LWT) and race (RACE=1:white, RACE=2: black, RACE=3:other). The dependent variable is coded 1 for birth weights less than 2500 gms. and coded 0 otherwise. Instead of considering LWT itself we are taking LWD, a dummy variable coded 1 if LWT is less than 110 pounds and coded 0 otherwise.

Our model is simple regression of LOW on a constant, LWD and RACE.
To perform Logistic regression, from the menus choose;
Analyze
  Regression
    Logit
      Estimate Model…



- Select *FALL* as the **Dependent** variable.
- Select *DIFFICULTY* and *SEASON* as the **Independent** variables**.**

The categorical values encountered during processing are
Variables ¦ Levels
---------------+--------------
LOW (2 levels) ¦ 0.000 1.000

Binary LOGIT Analysis
Dependent Variable : LOW
Input Records : 189
Records for Analysis : 189

Sample Split

Category Choices	
0 REFERENCE	130
1 RESPONSE	59
Total	189

Log-Likelihood Iteration History

Log-Likelihood at Iteration1	-131.005
Log-Likelihood at Iteration2	-112.159
Log-Likelihood at Iteration3	-111.995
Log-Likelihood at Iteration4	-111.995
Log-Likelihood at Iteration5	-111.995
Log-Likelihood	-111.995

Information Criteria

AIC	229.989
Schwarz's BIC	239.715

Parameter Estimates

Parameter	Estimate	Standard Error	Z	p-value	95 % Confidence Interval Lower	Upper
1 CONSTANT	-1.535	0.380	-4.043	0.000	-2.278	-0.791
2 RACE	0.263	0.176	1.501	0.133	-0.081	0.607
3 LWD	0.982	0.366	2.681	0.007	0.264	1.700

Odds Ratio Estimates

Parameter	Odds Ratio	Standard Error	95 % Confidence Interval Lower	Upper
2 RACE	1.301	0.228	0.923	1.836
3 LWD	2.671	0.978	1.302	5.476

Log-Likelihood of Constants only Model = LL(0): -117.336
2*[LL(N)-LL(0)] : 10.683
df : 2
p-value : 0.005

McFadden's Rho-squared	0.046
Cox and Snell R-square	0.055
Naglekerke's R-square	0.077

Covariance Matrix

	1	2	3
1	0.144		
2	-0.058	0.031	
3	-0.023	-0.007	0.134

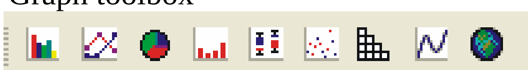
Correlation Matrix

	1	2	3
1	1.000	-0.867	-0.165
2	-0.867	1.000	-0.108
3	-0.165	-0.108	1.000

Conclusion. We see that only RACE is significant. The likelihood-ratio statistic of 10.683 is chi-squared with two degrees of freedom and a p-value of 0.005.

Graphs

SYSTAT offers a wide variety of graphical analysis tools that enable better visualization of the data. The editing options in SYSTAT allow you to fine-tune and change the display of the graph. To create Summary charts, Density displays, Plots click on the graph toolbar menu or select the icon from the Graph toolbox



Note. Graph menus are available when a data file is in use.

Example: Simple Scatter Plot. Let us create a simple scatter plot. Consider the following data file. In various international cities, how long must people work to earn enough to buy a Big Mac? How does this time relate to the length of a typical work week? We plot *BIG_MAC*, the working time (in minutes) to buy a Big Mac against *WORKWEEK*, the length of the work week (in hours). The data are in the **RCITY** file that has 46 cases, one for each city.

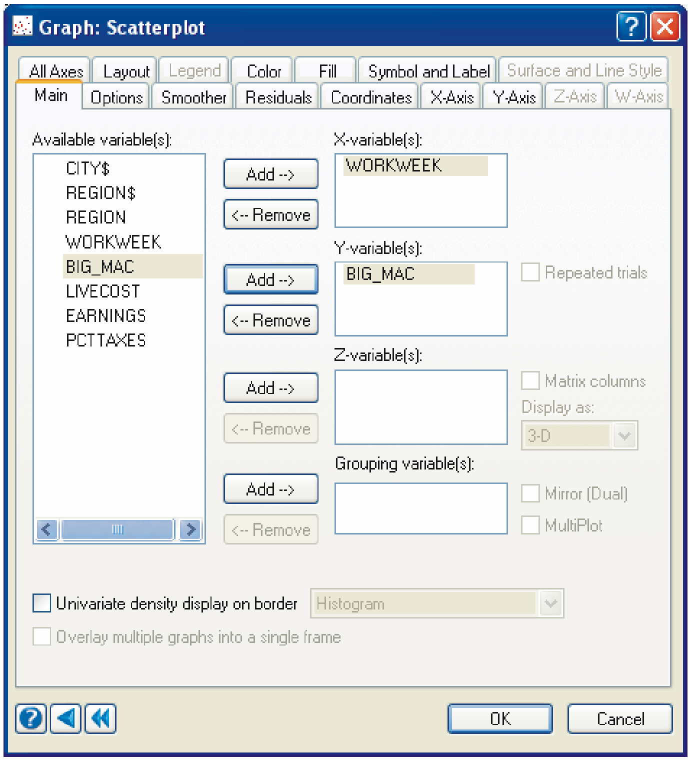
Open the *RCITY.SYZ* data file from DATA folder of main SYSTAT directory.

Note. By default, the file location is "C:\Program Files\SYSTAT 12\Data"
You can also change the default path. To do so, from the menus choose:

- **Edit →Options.**
- Select the **File Locations** tab**.**
- Select the radio button, **Set custom directories.**
- Change the path for **Open data.**

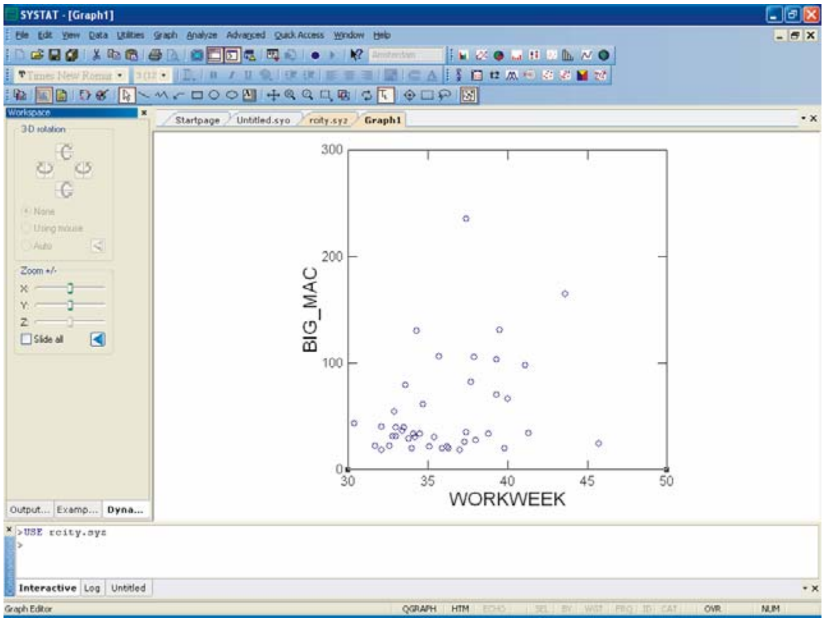
To plot *Big_Mac* against *WORKWEEK*, from the menus choose:

Graph
Plots
Scatterplot…



- Select *WORWEEEK* as the X-variable(s).
- Select *BIG_MACK* as the Y variable.
- Click OK.

The Output Editor displays the following graph:



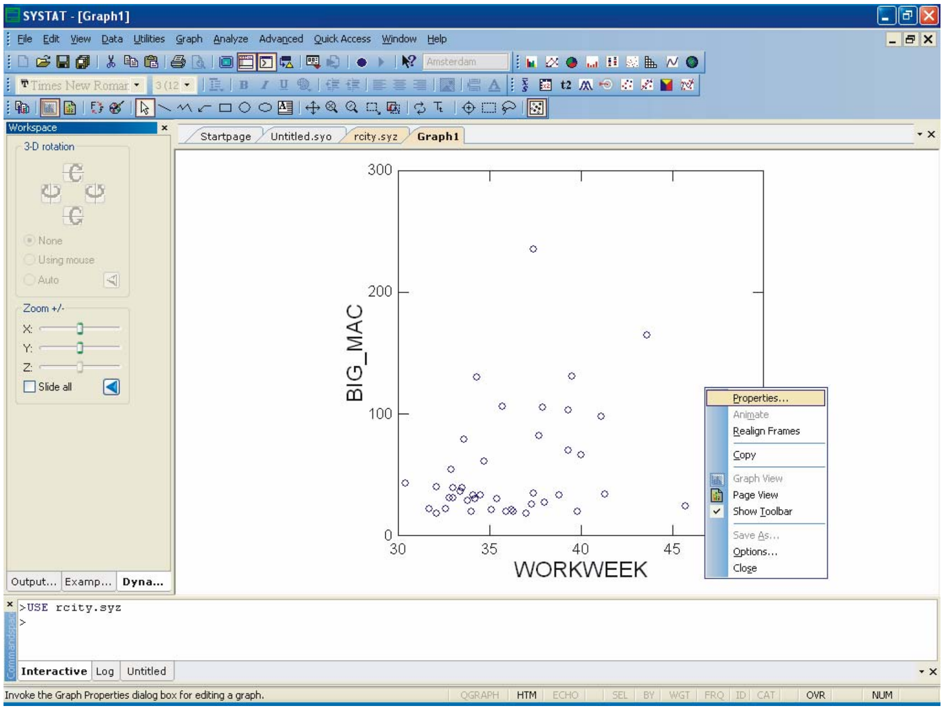
Customization of an existing graph

Once you have created a graph, you can use the Graph Editor tab to change many of its features without recreating the graph. Using the Graph menu, you can change the properties such as color, axes, labels, symbols, titles and graph size.

Note: To view the graph in the **Graph Editor**, either double-click on it or click the **Graph Editor tab** or double click the corresponding node in the tree formed in the **Output Organizer**.

➢ To Edit Graph Axes

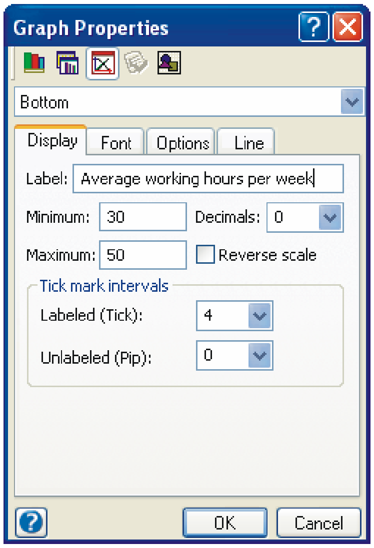
For editing graph axes as well as editing the graph as a whole you can use Graph Properties Dialog Box in the Graph Editor. To open the Graph Properties Dialog box, double-click on the Graph Editor. You can also right-click on the Graph Editor, open a menu with item 'Properties' at the top and click 'Properties' to open Graph Properties dialog box. Through the Graph Properties dialog box you can modify features of a graph, frame, axis, legend and element.



For editing graph axes select the **Axes** page of the Graph Properties dialog box.
The Axes dialog enables you to alter the axes of your graphs. It has four tabs **Display, Font, Option** and **Line.**

Suppose now you find that X-axis label 'WORKWEEK' is difficult to comprehend and you want to make it more explanatory by changing the label, using the Graph Properties dialog box. Select the **Display** tab.

Display tab



- To enter the new label for the x-axes select \`bottom' from the drop down list.
- Change the *WORKWEEK* in the **X-axis label** to *Average working hours per week.*
- Click Ok.

Now the X-axis label will be changed into AVERAGE WORKING HOURS PER WEEK.If you want to change the labels of other axes also proceed in a similar way.

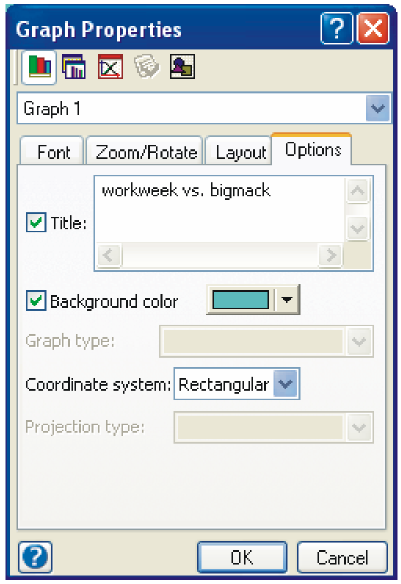
Note: Using the same dialog box you can specify suitable ranges for different axes using the **Minimum** and **Maximum** boxes. For a better specification, you can specify the number of 'Tick Mark Intervals' you want using the **labeled(Tick)** and **Unlabeled(pip)** boxes.

You can also give a title for the graph using the same dialog box.

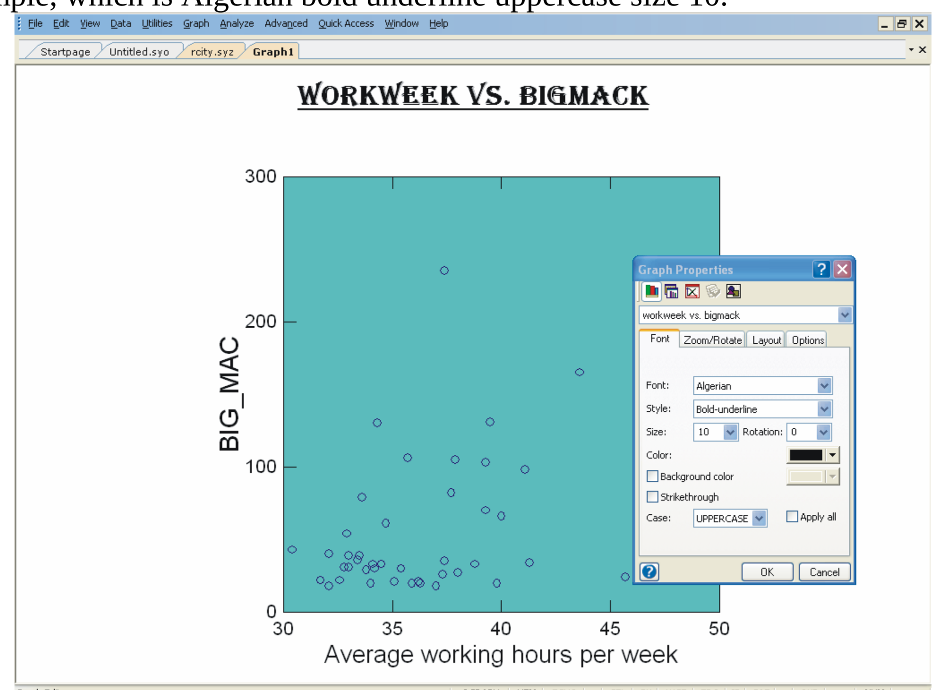
- Go to the **Graph** page.
- Click **Options** tab.
- Check the **Title** box.
- Enter a new title for your graph, say, WORKWEEK vs. BIG_MACK.

For a better presentation, you may want to color the graph.

- Check **Color** box and select a suitable color.



You can also select a suitable font for the graph title by using the **Font** option. See this graph as an example, which is Algerian bold underline uppercase size 10.



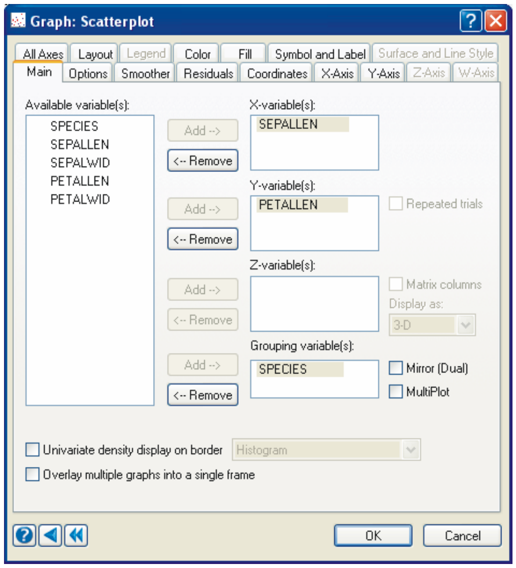
Thus the Graph Properties Dialog box enables you to edit graphs in various modes.

Example: Fisher's IRIS Data

We again use the famous IRIS data set from Fisher and explore it graphically. We have already found that SEPALLEN and PETALLEN have the strongest correlation for SPECIES 3 (i.e., Virginica). Now you may want to know: are these two variables vary substantially for different species?

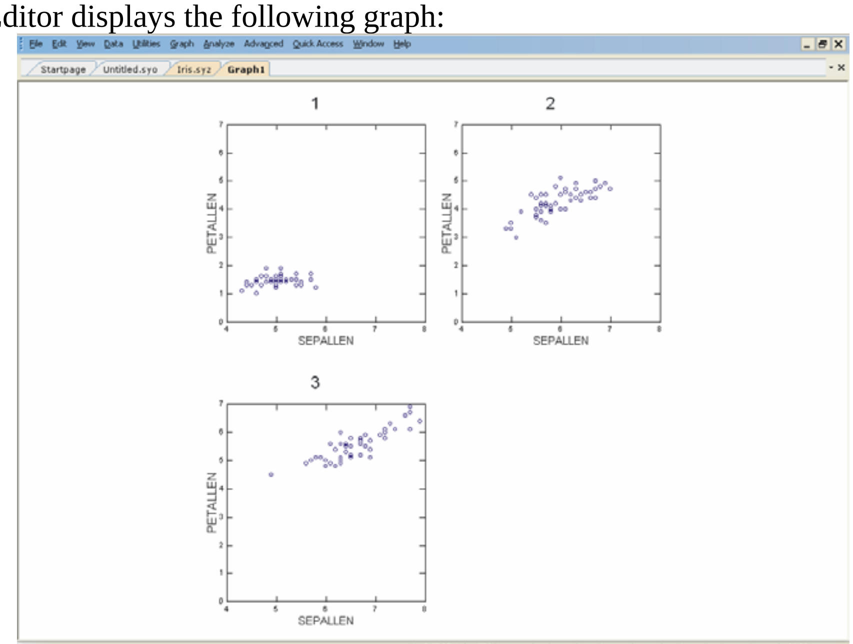
Let us try to answer this question graphically.

Open IRIS from the data folder.
From the menus choose:
Graph
Scatterplot…



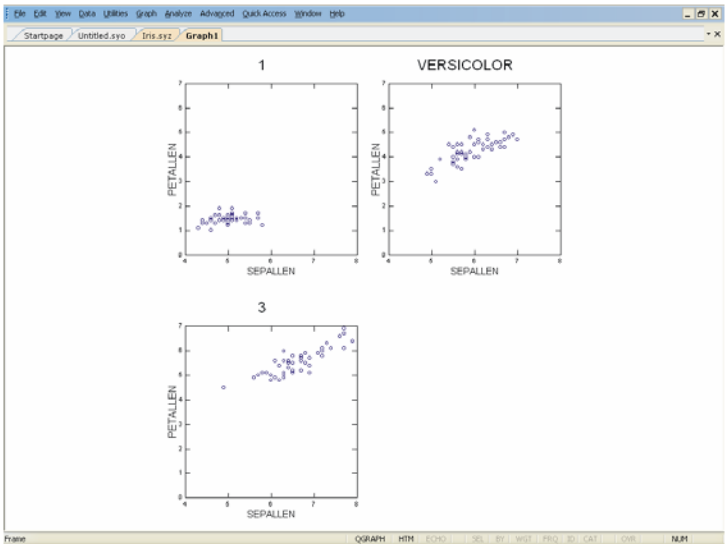
- Select SEPALLEN as the X-variable(s) and PETALLEN as the Y-variable(s).
- Select SPECIES as the Grouping variable(s).
- Click OK.

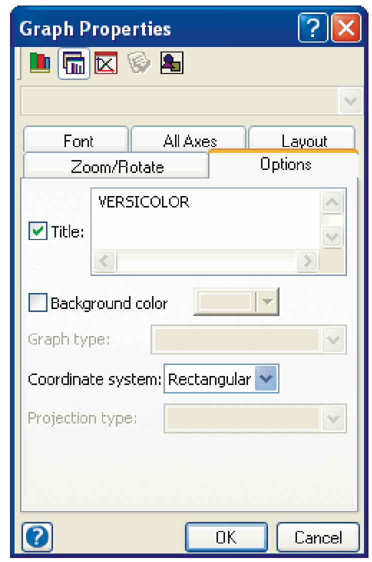
The Output Editor displays the following graph:



Suppose you want to enter a title for individual frames, e.g., add a title 'Versicolor' for *SPECIES 2*.

- Click the scatterplot for *SPECIES 2*.
- Open the **Frame** page of Graph Properties dialog box.
- Click **Options** tab.
- Check **Title** box.
- Write VERSICOLOR.
- Click OK.

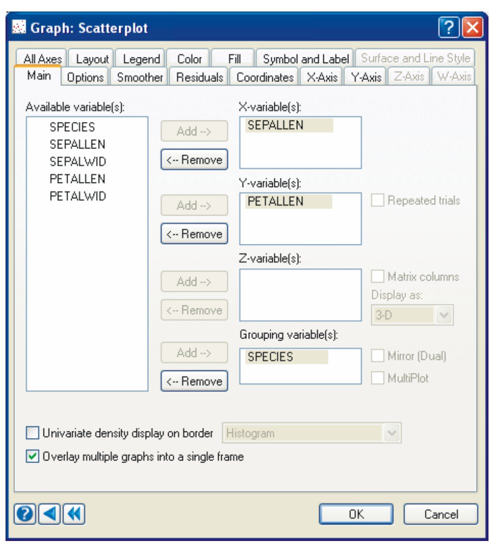




Now from the graph it appears that *PETALLEN* and *SEPALLEN* vary substantially for different *SPECIES*. For getting a better impression, it may be useful to plot them on a common graph. For thism from the menus choose:

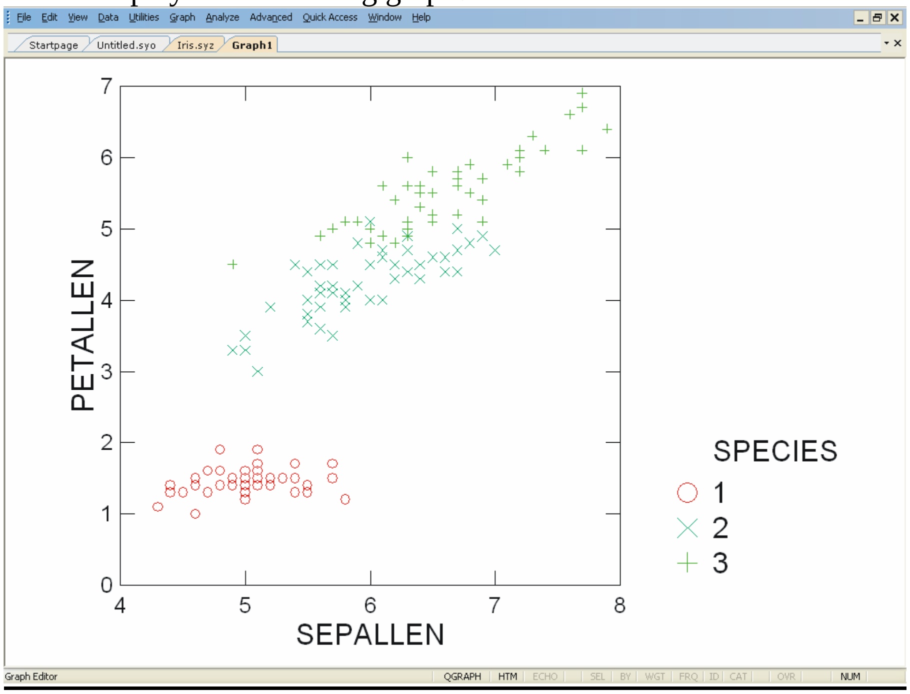
Graph

Scatterplot…



- Select *SEPALLEN* as the X-variable(s) and *PETALLEN* as the Y-variable(s).
- Select *SPECIES* as the Grouping variable(s).
- Check the Overlay mode.
- Click OK.

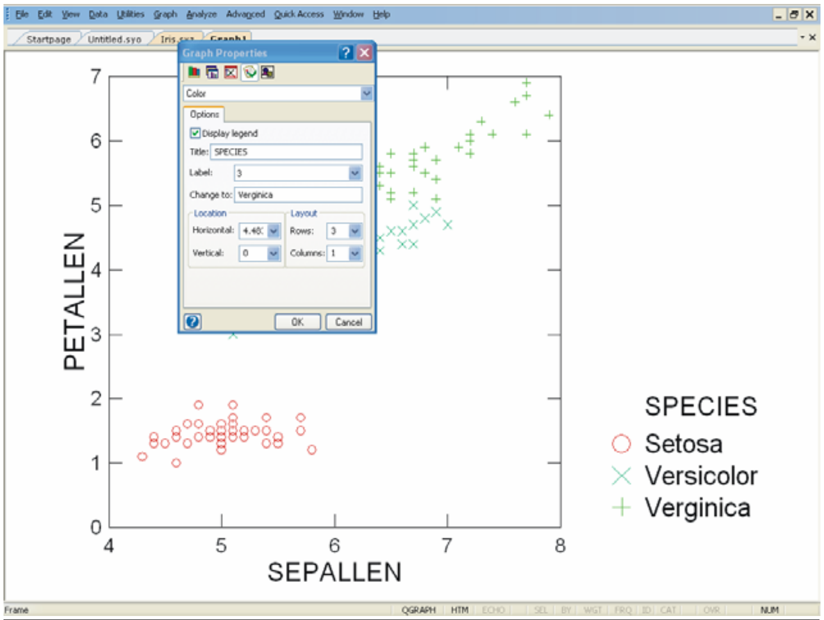
The Output Editor displays the following graph:

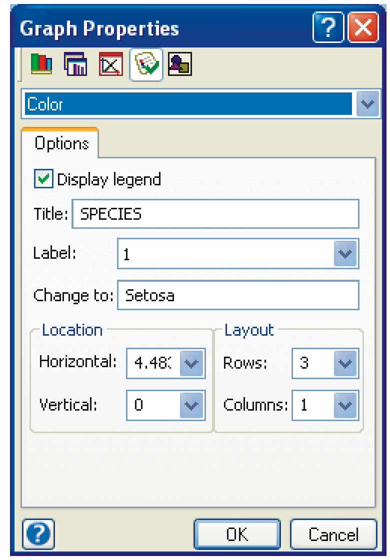


Now from the graph it is clear that *PETALLEN* and *SEPALLEN* vary significantly from one species to another.

Now if you want to label the SPECIES go to the **Legend** page of the Variable Properties dialog box. Note that in the Overlay mode, **Legend** tab is activated.

- Select ‘1’ from the drop-down list of **Label.**
- Write ‘Setosa’ in the **Change to** box.
- Select ‘2’ from the drop- down list and write ‘Versicolor’.
- Select ‘3’ from the drop-down list and write ‘Virginica’.



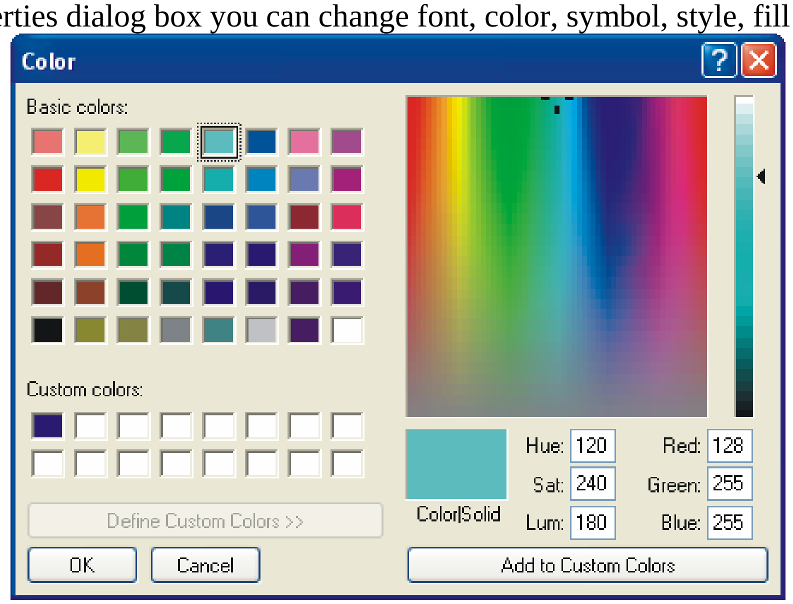


In the Graph Editor, the legend labels are changed accordingly. Note that if you do not want to display legends, just uncheck the **Display legend** checkbox. You can also choose the symbols for different *SPECIES*.

➢ **To Edit Appearance of the Graph:**

We have already customized some aspects of the appearance of a graph. Here are some more aspects:

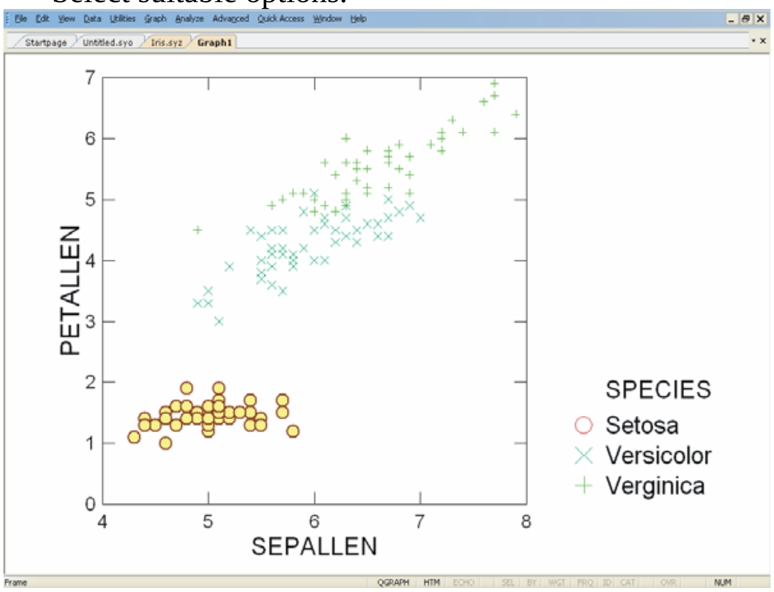
The **Variable Properties** dialog box will enable you to customize some more aspects. Using the Graph Properties dialog box you can change font, color, symbol, style, fill pattern etc.

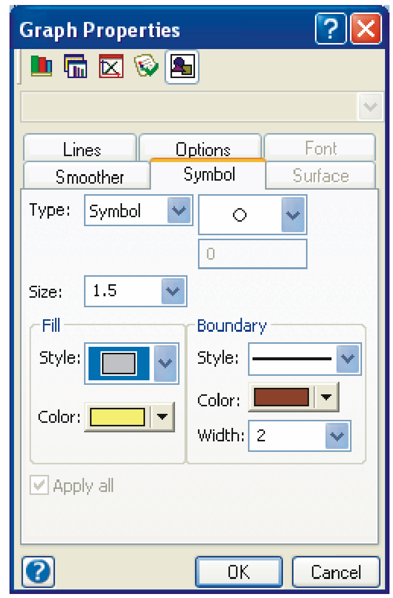


SYSTAT allows you to set color for fonts, symbol fill, symbol boundary, tick marks, axes lines, and elements, by choosing a color from the color palette that pops up by pressing of the corresponding color picker button. In the Color Palette, apart from the 48 predefined colors, you can access more than 16 million colors using Define Custom Colors. Simply specify the RGB (Red-Green-Blue) or Hue-Sat-Lum (Hue-Saturation-Luminosity) values, use the slider on the right to adjust the shading and press Add to Custom color.

Suppose you want to highlight the points for SETOSA *SPECIES*.

- Select Setosa from the drop-down list of labels.
- Go to the **Elements** page.
- Click the **Symbols** tab.
- Select suitable options.



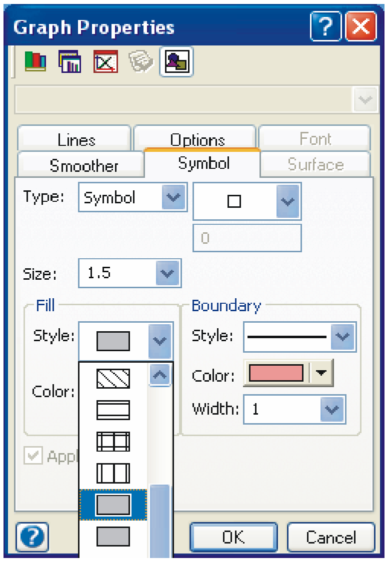


Note: The above menus are also available in the main Scatterplot dialog box.

- To change the color of the elements in the graph, select the option **Select color.**
- Select a color from the **Color** drop-down list for each of the y variables.
- Select the fill pattern from **fill** tab.
- Select the symbols from **symbol** tab.

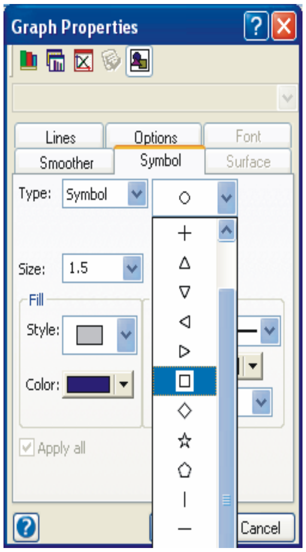
<u>Fill</u>

- To change the fill pattern for the elements in a graph, select the option **Select fill.**
- Select a fill pattern from the **Fill Pattern** drop-down list for each of the y variables.



<u>Symbol and Label</u>

- You can change the symbol type by using any of SYSTAT's 23 built-in symbols.



Getting Help

SYSTAT uses the standard HTML Help system to provide information you need to use SYSTAT and to understand the results. This section contains a brief description of the Help system and the kinds of help provided with SYSTAT.

The best way to find out more about the Help system is to use it. You can ask for help in any of these ways:

- Click the button  in a SYSTAT dialog box. This takes you directly to a topic describing the use of the dialog box. This is the fastest way to learn how to use a dialog box.
- Right-click on any dialog box item, and select 'What's this?' to get help on that particular item.
- Select Contents or Search from the Help menu.
- For help on commands, from the command prompt (on the Interactive tab of the Commandspace) type:

```
HELP [command name]
```

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