MathConnex

Getting Started Guide

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Chapter 1
About MathConnex

Welcome to MathConnex! This chapter provides a brief overview of MathConnex and how you use it with Mathcad, other computational programs, and data sources.

What is MathConnex?

Basic features and operation.

Using MathConnex

Suggested uses with Mathcad and other applications or data sources.

Additional sources of information

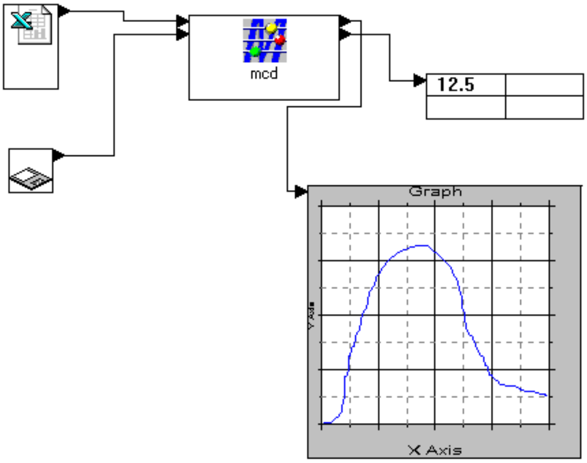
Where to get help on MathConnex if you need it.

What is MathConnex?

MathConnex™ is an environment for visually integrating and linking applications and data sources to create heterogeneous computational systems. By providing visual components for each data source or application in a system—such as a Mathcad component, an Excel component, and a File Read/Write component—MathConnex lets you manage the flow of data from one application or data source to another.

You can easily create a system consisting of Mathcad worksheets, other applications, and data sources by:

- Dragging components from the Component Palettes and dropping them into the MathConnex Worksheet.
- Wiring the components together to indicate data flow.
- Using Toolbar controls to run the system.



You can think of each visual component in the system as a separate object or process, receiving input, calculating, and producing output. MathConnex seamlessly handles all the data passing and process execution, allowing you to focus on the system as a whole.

MathConnex features

MathConnex makes it easy for you to design, activate, and publish systems of applications and data sources by allowing you to:

- Access 16 visual components for importing and exporting data, for performing calculations and viewing results, and for controlling the flow of data from one component to the next.
- Drag and drop components into the Worksheet.

- Capture a group of connected components as a module to use in other projects.
- Integrate and manage data and computations between different applications.
- Perform mathematical calculations using Mathcad, Excel, Axum, and MATLAB®.
- Analyze and debug calculations.
- Compute using the ConnexScript™ math programming language.
- Script embedded OLE components using VBScript or JScript.
- Work productively in a truly customizable and extensible environment.

Using MathConnex

Given the variety of components available for integration into a system, you can use MathConnex to design an endless number of different systems involving different applications and data sources. For example, you can use MathConnex to:

- Integrate Mathcad with other applications such as Excel and MATLAB.
- Chain Mathcad worksheets together and pass data from one to the next.
- Break a large Mathcad worksheet into several smaller worksheets and connect them in MathConnex. Use conditionals to control the flow from one to another.
- Loop through a Mathcad worksheet by passing the output from a worksheet back into itself as input.
- Facilitate the development of a large project: break it up into subsections, design each as a MathConnex module, and assemble the subsections into a MathConnex project.

A note about other applications

The built-in group of components in MathConnex includes several designed especially to work with other computational programs: MathSoft's Mathcad and Axum, Microsoft Excel, and MATLAB from The MathWorks. Because MathConnex is installed with Mathcad 7 Professional, you'll always be able to use the Mathcad component. To use the other computational components, you'll need to have installed an appropriate version of the corresponding application on your system: Axum 5.0b, Excel for Windows 95 or later, or MATLAB 4.2. See the Release Notes accompanying your Mathcad installation media for current compatibility information.

A note about performance and memory

To run MathConnex, you should have at least 16 megabytes of memory installed on your computer. Be aware that many MathConnex components are specialized OLE objects that allow you to connect to an application or data source. Using these components therefore requires additional memory, as well as additional processing power, to run the application with which it is associated. To use the Mathcad and Excel components together in MathConnex, for example, we recommend that you have at least 32 megabytes of memory installed on your system.

Additional sources of information

This guide is designed to provide you with enough information so that you can immediately begin creating and running systems in MathConnex. Other sources of information include the on-line Help system and the sample modules and projects provided with MathConnex, plus updates on MathSoft's World Wide Web site.

To open the on-line Help:

- Choose **MathConnex Help** from the **Help** menu.
- Use the Contents tab to locate a topic in the Table of Contents. Use the Index and Find tabs to search on a particular word or topic.

To access the sample MathConnex projects:

- Choose **Open** from the **File** menu.
- Double-click on the **`samples`** folder.
- Select a project (.MXP file) and click "Open."

To access the sample MathConnex modules:

- Click on the Modules tab in the MathConnex Explorer.
- Open the Sample Modules folder.
- Drag and drop a module from the MathConnex Explorer to the Worksheet.

For updated information about MathConnex, including additional sample projects, visit the following address on MathSoft's World Wide Web site:

`http://www.mathsoft.com/mcadlib/mathconnex/`

Chapter 2
The MathConnex Workspace

The MathConnex workspace is your interface for accessing computational *components,* connecting components into *systems* in the MathConnex worksheet, arranging and sharing systems and other OLE objects as MathConnex *projects*, and reusing *modules*.

This chapter has the following sections:

Starting MathConnex

What you see when you launch MathConnex.

Menus, Toolbar, and Status Bar

The MathConnex command interface.

Component Palettes

Drag-and-drop interface for the basic MathConnex components.

The Worksheet

Where you create systems, projects, and modules.

The MathConnex Explorer

An interface for arranging available modules and components and for seeing the components in the current project.

Starting MathConnex

MathConnex is installed when you install Mathcad Professional. Start MathConnex by clicking on the MathConnex button in the Mathcad Professional Toolbar, or launch MathConnex as you would other Windows applications. The MathConnex workspace is then displayed in a window like the one in Figure 2-1.

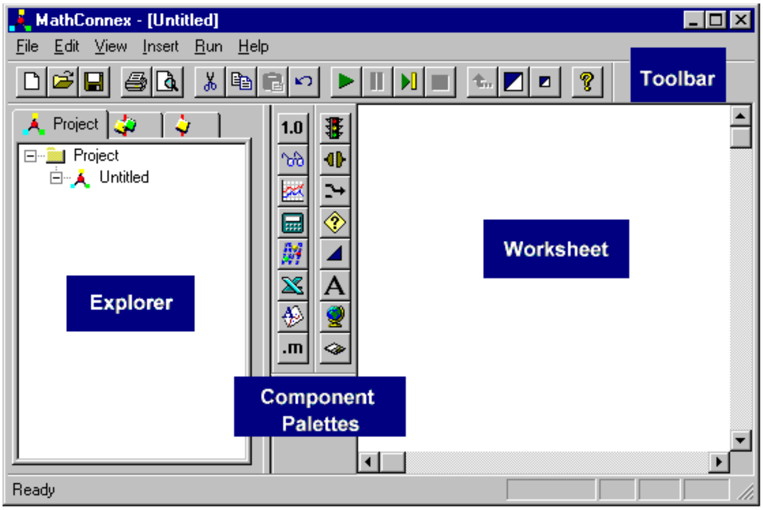


Figure 2-1: The MathConnex workspace.

The following sections introduce:

- Menu commands, the Toolbar, and the Status Bar.
- The two Component Palettes, your interface to the computational tools of MathConnex.
- The Worksheet, where you create computational systems from components.
- The MathConnex Explorer, an object browser where you manage projects and modules.

The Toolbar, Component Palettes, and Explorer can be resized, dragged off the application window, or docked again (reattached) to various borders of the MathConnex window. Use commands on the **View** menu to toggle the display of the Toolbar, Component Palettes, Status Bar, and Explorer.

Tip You can undock a docked element of the workspace, like the Toolbar, by double-clicking on its border.

Menus, Toolbar, and Status Bar

Menu commands

File Menu

New	Begin a new MathConnex project.
Open...	Open an existing MathConnex project.
Save	Save a MathConnex project.
Save As...	Save a MathConnex project to a different filename.
Print Setup...	Define the properties for printing a project.
Print Preview	Display a replica of what the project will look like when it is printed.
Print...	Print the active project.
Send...	Attach a copy of the current project to an e-mail message. The recipient of the mail must have properly installed MathConnex software to view the project.
Recent Files	Open most recently saved MathConnex projects.
Exit	Close MathConnex.

Edit Menu

Undo	Undo the last command.
Redo	Redo the last command.
Cut	Remove the selected object(s) from the Worksheet and place in the Clipboard.
Copy	Place a copy of the selected object(s) on the Clipboard.
Paste	Insert the contents of the Clipboard into the Worksheet.
Object	Activate embedded or linked object.

View Menu

Toolbar	Toggle the display of the Toolbar.
Status Bar	Toggle the display of the Status Bar.
Explorer	Toggle the display of the Explorer.
Component Palette 1	Toggle the display of eight built-in component buttons.

Component Palette 2	Toggle the display of eight built-in component buttons.
Go Back	Go to higher level of worksheet when a collapsed subsystem is being viewed.
Zoom In	Increase the scale of the Worksheet display to magnify the objects on the Worksheet.
Zoom Out	Decrease the scale of the Worksheet display to reduce the size of the objects on the Worksheet.
Show Labels	Toggle the display of labels on components in the Worksheet.

Insert Menu

Component...	Launch Wizard to insert component into the Worksheet.
Object...	Insert an OLE object into the Worksheet.
Scripted Object...	Launch Scripting Wizard to insert a scripted component into the Worksheet.

Run Menu

Run	Run the system contained in the Worksheet.
Pause	Pause a running system.
Step	Run the next component connected in the Worksheet.
Stop	Stop a running or paused system.
Single Step Mode	Toggle the execution of parallel systems to be sequential or concurrent. (See Chapter 5, “Advanced Topics.”)
Highlight Components	Toggle the highlighting of the component currently being calculated during the run.

Help Menu

MathConnex Help...	Show MathConnex Help topics.
Tip of the Day	Display tips for using MathConnex.
About MathConnex...	Display program information, version number, and copyright.

Toolbar buttons

The Toolbar contains buttons for shortcut access to the following commands:

🗋	**New**	Open blank Worksheet for a new MathConnex project.
📂	**Open**	Open an existing MathConnex project.
💾	**Save**	Save a MathConnex project to a .MXP file.
🖨	**Print**	Print the active project.
🔍	**Print Preview**	Display a replica of what the project will look like when it is printed.
✂	**Cut**	Remove the selected object(s) and place them in the Clipboard.
⎘	**Copy**	Send a copy of the selected object(s) to the Clipboard.
📋	**Paste**	Insert the contents of the Clipboard into the Worksheet.
▶	**Run**	Run the system contained in the Worksheet.
⏸	**Pause**	Pause a running system.
⏭	**Step**	Run the next component connected in the Worksheet.
■	**Stop**	Stop a running or paused system.
↰	**Back**	Go to a higher-level worksheet.
◩	**Zoom In**	Increase the scale of the Worksheet.
◪	**Zoom Out**	Decrease the scale of the Worksheet.
?	**Help**	Show MathConnex Help topics.

Status Bar

The Status Bar at the bottom of the MathConnex window describes the current operation whenever you select a menu command. Look in the right-hand part of the Status Bar to see the *run mode* of the system you have on the Worksheet:

- **RUN** – the system is currently executing
- **PAUSE** – execution has been paused
- **STOP** – execution has been stopped

Component Palettes

MathConnex comes with more than a dozen built-in components, displayed on two palettes, for you to use in building your systems. To use a component from one of the Component Palettes:

- Click and hold the left mouse button on a component in the Component Palettes.
- Drag the component to the location you want in your Worksheet.
- Release the mouse button.

Some components will launch a Setup Wizard to guide you through initial configuration of input and output ports and other properties. For others, you will need to assign properties manually. For details on the components listed below, see Chapter 4, “Components.” The Scripted Object component is taken up in Chapter 5, “Advanced Topics.”

Components to generate, import, or export data

1.0	**Input**	Input a single value or an array in a scrollable table.
	File Read or Write	Input data from or output data to a file.
◢	**Ramp**	Generate a sequence of equally spaced values.
	Global Variable	Input a value accessible by any component in the system.

Components for viewing results

	Inspector	Inspect data values in a scrollable table.
	Graph	Graph one or more data points.
	Axum	Display an Axum 2D or 3D plot, if Axum is installed on your system.

Computational components

	Mathcad	Compute with Mathcad.
	Excel	Compute with Excel, if installed on your system.
.m	**MATLAB**	Compute with MATLAB, if installed on your system.
	ConnexScript	Compute using commands in the ConnexScript language.

Components for controlling data flow

Conditional	Conditionally route data to output ports.
Initialize	Take initial value from one input port and subsequent values from another.
Wire Breaker	Break (interrupt) data flow along the wire.
Stop or Pause	Pause or stop running a system.

Other components

Text	Create text region for annotation.

The Worksheet

In the Worksheet of MathConnex you:

- Design, run, analyze, and edit one or more MathConnex *systems*.
- Change your view by zooming or by collapsing *subsystems*.
- Annotate your MathConnex systems with text or other OLE objects.
- Save, print, or e-mail the Worksheet contents as a MathConnex *project*, and save groups of configured, connected components as *modules*.

Systems

In MathConnex you have a single Worksheet to work with, although you may have as many systems on it as you like. As described on page 16, however, you can hide complexity in the Worksheet by collapsing a group of components into a subsystem, and a subsystem itself may have other subsystems. A Worksheet may therefore have a hierarchy of components.

Figure 2-2 shows a MathConnex system in the Worksheet that models a double pendulum. Turn to Chapter 3, “Creating and Running a System,” for a step-by-step example of creating a MathConnex system. You typically follow these steps in creating a system:

- Plan the components and external files that the system will need, and anticipate what the output of the system will be: a file, data to be viewed, a graph, etc.
- Place components on the Worksheet by dragging and dropping them from the Component Palettes, or by choosing **Component** from the **Insert** menu.

- Configure the components you have placed on the worksheet using options on the component context menus. You access the context menu for a component by clicking on it with the *right* mouse button. You decide on the correct number of inputs and outputs for each and choose display properties and other options.
- Wire the components together, connecting an output port from one component to the input port of another, so that data flows correctly from component to component.
- Run and stop the system, using the ▶, ⏸, ⏭, and ■ Toolbar buttons or the corresponding commands on the **Run** menu.
- Modify the system as needed: change the properties of components, change the wiring of components, change the data sources or data outputs.

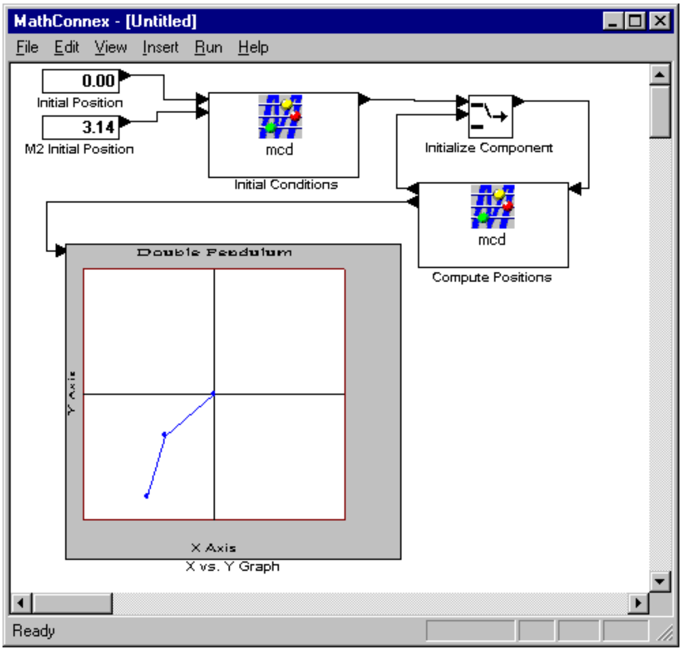


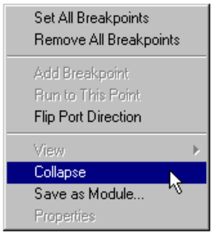
Figure 2-2: A MathConnex system in the Worksheet.

Changing your view on the Worksheet

Because systems with more than a few components may be too complex to view easily on the screen, MathConnex provides several ways to simplify or change the view of your Worksheet. You can:

- Scroll to view a different part of the Worksheet, using the scrollbars.
- Zoom in and out of areas on the Worksheet, using the ◪ and ◘ Toolbar buttons or the corresponding **View** menu commands.

- Collapse the display of one or more components into a *subsystem* on your Worksheet. In this way you hide or nest details about the components in your system and create an additional *level* in the Worksheet.



To create a subsystem in your system, select one or more components in the Worksheet, click on the selected components with the right mouse button to see the context menu, and choose **Collapse**.

You may create as many levels as you like in your Worksheet by collapsing component groups. MathConnex displays a collapsed subsystem using a subsystem icon in the Worksheet, but the components in the subsystem continue to have the properties and connections they had before you collapsed the view. The system will run exactly as it did before you collapsed the components.

To see and edit the contents of the subsystem, double-click on the subsystem icon, which opens up a new Worksheet level containing the components of the subsystem but in which other components of the system aren't editable. MathConnex displays the ↳ icon in this view to indicate that the system contains components at other levels. To return to the Worksheet level in which the subsystem displays as an icon, choose **Go Back** on the **View** menu or click the ⬆ Toolbar button.

You can *lock* a subsystem so its contents can only be viewed and edited after a password is entered. To do so, click on the subsystem icon with the right mouse button and choose **Lock** from the context menu. Enter a password in the dialog box. You will be prompted for the password the next time you try to view the contents of the subsystem.

When you create a subsystem, and especially if you have locked it, you'll usually want to leave any components in it hidden when you run the system. To view a particular subsystem component in a higher Worksheet level, however, do the following:

- Open the subsystem containing that component as described above.
- Click on the component once with the right mouse button.
- Choose **View** ⇒ **In Parent** from the context menu.

Now when you go back to the higher Worksheet level, you will see the corresponding component in place of the icon that otherwise denotes a collapsed subsystem. The component can only be edited, however, in the Worksheet level it came from.

To restore a subsystem to its uncollapsed appearance, click on the subsystem icon in the Worksheet with the right mouse button and choose **Expand** from the context menu.

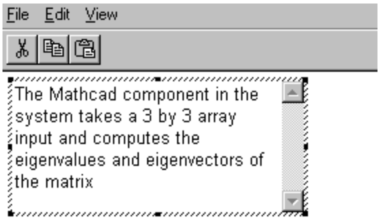
Annotating the Worksheet

The use of labels on components and modifying the appearance of components with icons or other OLE objects are described in the section "Changing the appearance of components" in Chapter 3. In addition to these options, MathConnex lets you annotate your Worksheet so that you can document your project and communicate your results to others. You can annotate the Worksheet with:

- Text regions created with the Text component
- OLE objects from other applications on your system

Text

The Text component lets you place an editable, scrolling region on the Worksheet containing any text you choose and displayed with a variety of formatting options. You place the text component on the Worksheet by dragging the A button from the Component Palettes. Then just start typing text in the region, as shown below:



The Mathcad component in the system takes a 3 by 3 array input and computes the eigenvalues and eigenvectors of the matrix

The Text component is comparable in functionality to the text annotation tool in Microsoft Paint (an accessory normally found in Microsoft Windows). See Chapter Chapter 4, “Components,” for details.

OLE objects

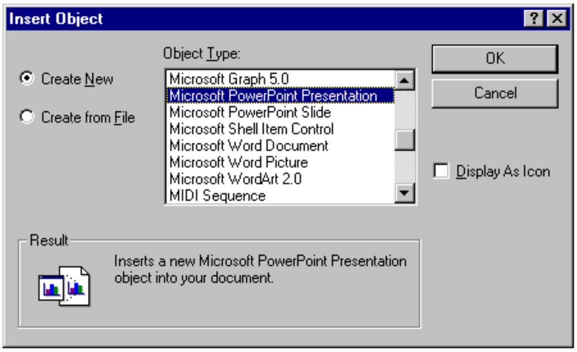
The MathConnex Worksheet is also a versatile OLE2 container, so you can embed or link objects created by other OLE-compatible applications on your system. For example, you can embed a document created by Microsoft Word to describe the systems in the Worksheet, and double-click on the embedded document to activate Microsoft Word in place in the Worksheet for editing.

You place an OLE object in the Worksheet in one of several ways. For example:

- Simply drag an object from an OLE2-compatible application on your system and drop it onto the MathConnex Worksheet. This embeds an object in the Worksheet.
- Choose **Object** from the **Insert** menu.

When you choose **Object** from the **Insert** menu, MathConnex displays a dialog box listing available OLE servers on your system. You have three options:

- Select the Create New radio button to create a *new* object directly in the Worksheet.
- Select the Create from File radio button and browse to find a file to *embed* an object in the Worksheet. An embedded object does not update automatically when the source file changes, but you can double-click it to activate it for editing.
- Select the Create from File radio button, browse to find a file, and click the Link checkbox to *link* to an object. Here, changes to the source file will be reflected automatically in the object.



● Create New

○ Create from File

Object Type:

Microsoft Graph 5.0
Microsoft PowerPoint Presentation
Microsoft PowerPoint Slide
Microsoft Shell Item Control
Microsoft Word Document
Microsoft Word Picture
Microsoft WordArt 2.0
MIDI Sequence

Result

Inserts a new Microsoft PowerPoint Presentation object into your document.

Projects and modules

MathConnex is an interactive environment for creating computational systems, but you will often want to save your work, or portions of it, to edit or re-use at a later date, as well as share your systems and components with others. You can save:

- A MathConnex *project*, which is a working snapshot of all the systems and other objects in the MathConnex Worksheet.
- A MathConnex *module*, which is a preconfigured, prewired group of components.

Projects

To save your work as a MathConnex project, choose **Save** from the **File** menu, or click the 💾 button on the Toolbar. To save an existing MathConnex project under a different name, choose **Save As** from the **File** menu.

Note MathConnex uses .MXP as the default extension for MathConnex projects.

To print a MathConnex project, choose **Print** from the **File** menu, or click the 🖨 button on the Toolbar. The **Print Preview** command on the **File** menu allows you to view, scroll, and zoom your printed output before you send it to the printer. Use the **Print Setup** command on the **File** menu to choose and configure an available printer, select a paper size and source, and choose either portrait or landscape orientation for your printed output.

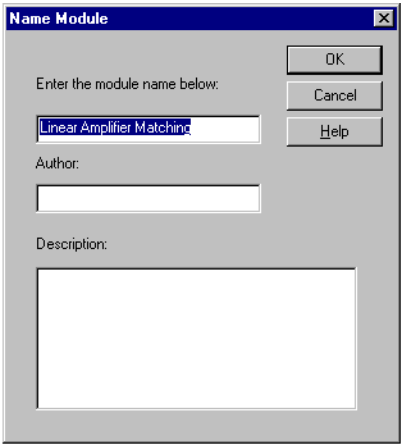
To send a MathConnex project as an attachment to an electronic mail message from a MAPI-compliant mail application such as Microsoft Mail, choose **Send** from the **File** menu. Your mail program launches with a blank message containing the current project as an attachment but waiting for you fill in the recipient, title, and other information.

Modules

To save a component or group of components to re-use in other MathConnex systems:

- Drag-select one or more components, or an entire system, in the Worksheet.
- Click with the right mouse button on one of the selected components.

- Choose **Save as Module** from the context menu, which displays the Name Module dialog box shown below.
- Enter a brief, descriptive name and other information about the module.



Enter the module name below: Linear Amplifier Matching

Author:

Description:

- Click “OK.” MathConnex saves the module in a default location.

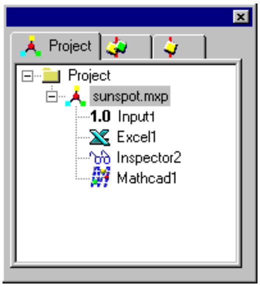
As described on page 21, you access, rename, import, and export available modules via the Modules tab in the Explorer.

The MathConnex Explorer

The MathConnex Explorer is an object browser for organizing the projects, modules, and components you can work with in MathConnex. The three tabs in the Explorer give you a tree display of:

- The contents of the project currently in the Worksheet.
- Available modules in your copy of MathConnex.
- Available components in your copy of MathConnex.

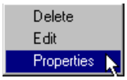
Project tab



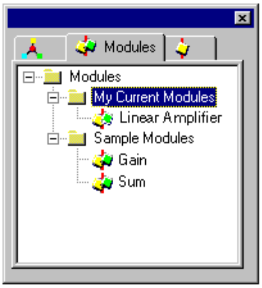
As you build a project in the Worksheet, the tree diagram in the Project tab expands to show the components you have used. Similarly, when you open an existing MathConnex project, all the components in the Worksheet are listed in the tree diagram. Although the project tree simply lists components and not the connections between them, it can be extremely useful for navigating large projects.

If you click on a component name in the project tree, the corresponding component in the Worksheet is displayed with a selection box.

Tip Click with the right mouse button on a component name in the project tree to access options for deleting, editing (activating), and assigning properties to the component in the Worksheet.



Modules tab



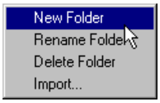
The Modules tab in the Explorer arranges available modules you can use in the Worksheet. Folders of modules are listed alphabetically, and modules within them are listed alphabetically by the names assigned to them in the Name Module dialog box.

When you want to use a module, simply drag and drop one of the modules listed here into the Worksheet.

To move a module into a different folder, drag it there.

MathConnex is shipped with a set of modules you can find in the Sample Modules folder.

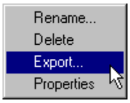
Tip To create a new subfolder in the Module tab, click with the right mouse button component on one of the folders and choose **New Folder** from the context menu. Also use this context menu to delete or rename a folder.



Exporting and importing modules

When you create a module, MathConnex saves it automatically for you in the `modules` folder of the location where you installed Mathcad and MathConnex. The module is added automatically to the tree in the Modules tab using whatever name you supplied in the Name Module dialog box.

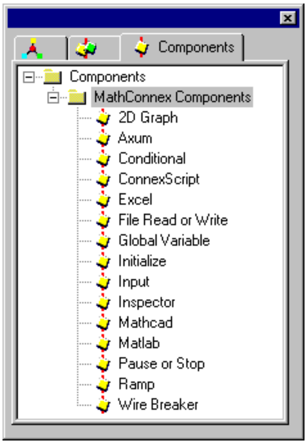
To share a module with someone else, first export it by clicking on the module name with the right mouse button and choosing **Export** from the context menu. You will be prompted for a location to save the Mathconnex module file.



Note MathConnex uses .MXM as the default extension for exported MathConnex module files.

To import a module file so that you can use it in your MathConnex workspace, click with the right mouse button on a folder name in the Module tab and choose **Import** from the context menu. Select a .MXM file from the dialog box. The module will then appear in the Modules tab.

Components tab



The Components tab lists shortcuts for available MathConnex components.

By default the Components tab has a MathConnex Components folder that lists all the components that were installed at the time you installed MathConnex. But you can arrange the components into any folders you want to; you add, delete, and rename folders in this tab just as you do in the Modules tab of the MathConnex Explorer.

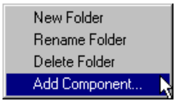
As an alternative to dragging and dropping one of the basic components from the Component Palettes, you can drag and drop one of the components listed here into the Worksheet.

To move a component to a different folder in the Components tab, simply drag it there.

Adding and deleting components

When you install MathConnex, all components that ship with the product are installed at that time and are available for use via the Component Palettes or the Components tab. You may later install components from MathSoft or other sources and want to be able to drag and drop them from the Explorer’s Component tab into the Worksheet.

To add a component to one of the folders in the Components tab, click with the right mouse button on a folder and choose **Add Component** from the context menu. The Components dialog box lists components that have been installed. Choose from one of the listed components in the dialog box to add a shortcut in the Components tab. You may add as many shortcuts to a component as you like.



To delete a component from the tree, click with the right mouse button on one of the components in the Components tab and choose **Delete** from the context menu or press the `[Del]` key.

Note Deleting a component from the tree in the Components tab does not physically delete the component from MathConnex. You can add it back later to the Components tab via the **Add Component** command.

Chapter 3
Creating and Running a System

This chapter teaches you how to use MathConnex to create and run a multicomponent system. The focus of the chapter is an example system in which data is brought into Mathcad for polynomial regression.

Overview

General information on creating a system.

Placing components on the Worksheet

Dragging and dropping components from the Component Palettes to the Worksheet.

Getting organized

Moving, copying and pasting, and deleting components. Resizing a component. Flipping the direction of a component’s ports.

Configuring the components

Using the Properties dialog to label and configure a component. Using other context menu options. Activating a component to edit it.

Wiring components together

Connecting and disconnecting components with wires.

Running and stopping a system

The basics of running and stopping a system. Highlighting active components. Stepping through a system component by component. Pausing a running system. Making a system run up to a certain component. Observing values as they pass through a wire.

Changing the appearance of components

Viewing a component as an icon or as another object. Showing labels.

Overview

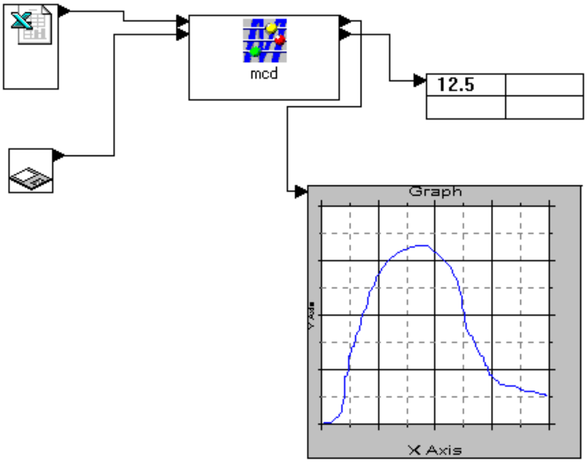
MathConnex lets you design systems of applications and data sources where each application and data source is a *component* in the system. The components are wired together so that when you run the system, data flows from one component to the next; the output data from one component becomes the input data for the next component. What each component does with the data as it passes through is determined by the type of component and how it was configured.

To create a system, you should first determine which components you'd like to use. See page 14 for a brief description of each of the available components. Refer to Chapter 4, "Components," for detailed information.

Once you've determined what components to use in a system, you will:

- Place the components on the Worksheet by dragging and dropping them from the Component Palettes.
- Arrange them appropriately on the Worksheet.
- Configure each component so that it knows what do with the data it receives and what data to send to the next component.
- Wire the components together by connecting the output port of one component to the input port of another.
- Run the system.

A completed system might look like this:



This chapter explains each of the steps involved in creating a system in more detail and describes a sample system for you to create. It also discusses how to change the appearance of a component to make it more appropriate for your project.

The example

In the sample system we will design in this chapter, data stored in an external data file is passed into a Mathcad worksheet. The Mathcad worksheet performs a second-order polynomial regression on the data and finds the coefficients of the second-order polynomial that best fits the data. Mathcad passes the coefficients and the value of R-squared, indicating how closely the data fit the polynomial, back into the system. The components involved in this system are:

- An Input component, for bringing in the data.
- A Mathcad component, for performing the polynomial regression.
- Two instances of the Inspector component, for displaying the coefficients and R-squared.

We will place these components on the Worksheet, configure them, wire them together, and run the system. The MathConnex project **`CURVEFIT.MXP`** located in the **`samples`** folder where you installed Mathcad and MathConnex shows a completed version of this example.

Although this example is fairly simple, it illustrates how you can use MathConnex to connect other applications and data sources to each other and pass data from one component to another. For instance, you can pass values into Mathcad from an Excel component, or you can send results from Mathcad to a MATLAB component, or to another Mathcad component, or to a data file. You can use the Conditional component to use different sets of data depending on whether the results satisfy a certain condition.

The number of possible systems you can create and their complexity are unlimited. To see more sophisticated examples involving a wider variety of components, browse the sample MathConnex projects located in the **`samples`** folder.

Placing components on the Worksheet

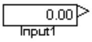
You can place components for a system on your MathConnex Worksheet by dragging and dropping them from the Component Palettes:

- Click the icon for the component in the Component Palettes.
- Hold the left mouse button down.
- Drag the icon to the Worksheet.
- Let go of the mouse button.

You will immediately see the component inserted into the Worksheet, or you will see a Setup Wizard dialog that walks you through initial configuration of the component.

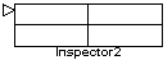
For example, place the Input component on your Worksheet using these steps:

- Drag the 1.0 icon from the Component Palettes to your Worksheet. The Input component appears:



Place two copies of the Inspector component on your Worksheet using similar steps:

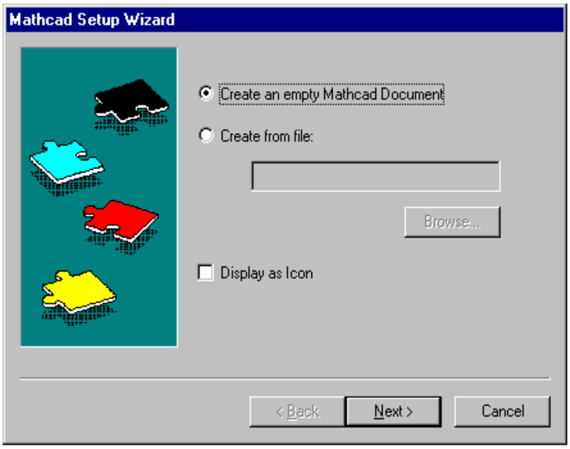
- Drag the icon from the Component Palettes to your Worksheet. The Inspector component appears:



- Drag the icon from the Component Palettes to your Worksheet again to insert another Inspector component.

Place the Mathcad component on your Worksheet:

- Make sure Mathcad 7 Professional is installed (but not necessarily running) on your system.
- Drag the icon from the Component Palettes to your Worksheet. This launches the Mathcad Setup Wizard:



Mathcad Setup Wizard

● Create an empty Mathcad Document

○ Create from file:

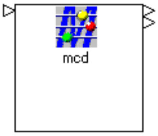
□ Display as Icon

This dialog box lets you specify whether you want to create a new Mathcad worksheet or use an existing one. For this example, we will use an existing worksheet that already has the necessary curve fitting equations entered in it.

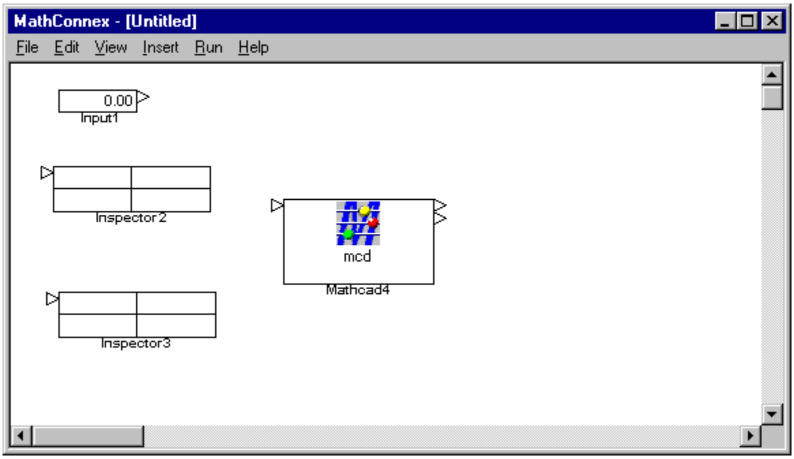
- Click "Create from file" and browse to find the file **`crvfit.mcd`** in the **`samples`** folder.
- Click "Open."
- Click the Display as Icon box. This inserts the Mathcad component as an icon instead of as a window on the Worksheet so we won't have to see all the curve fitting equations.

- Click on the "Next" button. The next page of the Wizard lets you specify the number of inputs and outputs. For this example, we will pass one set of data to the Mathcad component as input and we will send two sets of data out of the Mathcad component as output.
- Specify 1 input and 2 outputs.
- Click "Finish."

When you finish using the Wizard, you'll see an iconified Mathcad component in your Worksheet with one input port and two output ports:



Now you should see the Input component, two Inspector components, and the Mathcad component somewhere in your Worksheet, as shown below:



Getting organized

Once you've placed components on a Worksheet, you may need to move them around, resize them, or flip their port directions so that they fit best on the Worksheet. The following sections describe each of these operations in more detail.

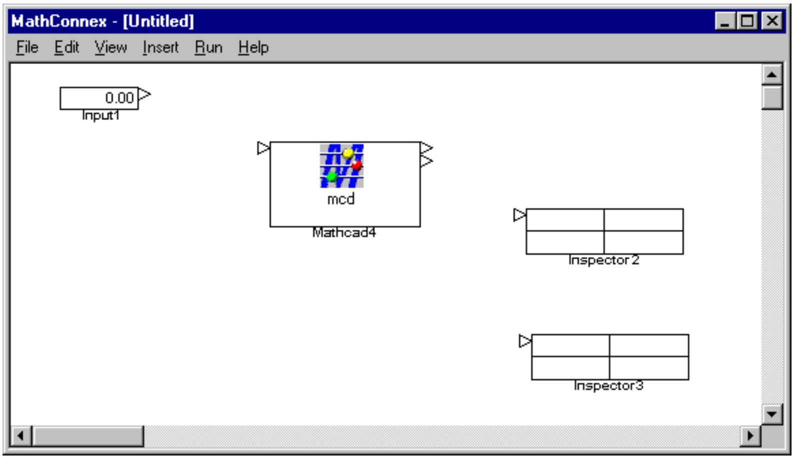
Moving a Component

To move a component:

- Click a component to select it.

- Hold down the left mouse button and drag the component to a new spot in the Worksheet. Any connecting wires adjust accordingly (although you may not have any at this point).

Try moving the Input, Mathcad, and Inspector components so that they are arranged this way:



Moving multiple components

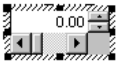
To move several components and maintain their connections:

- Position the mouse pointer outside the components you want to move.
- Hold the left mouse button down and drag a box around all the components you want to move.
- Release the mouse button.
- Click on any of the components, hold the mouse button down, and drag the component around the Worksheet. All the other components move with it. Any connecting wires adjust accordingly.

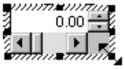
Resizing a component

You can see more or less of a component or you can stretch it. For example, to resize the Input component so that you see more of the table cells:

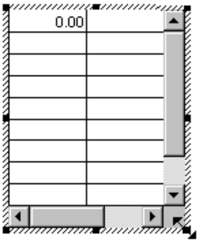
- Double-click on the component to activate it.



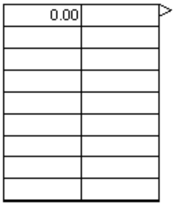
- Move the cursor to one of the handles that appear until it changes to a double-headed arrow.



- Hold the left mouse button down and drag the cursor in the direction you want the component's dimensions to change.

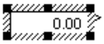


- Let go of the mouse button.

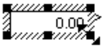


To stretch a component:

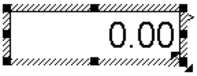
- Click once on it to select it (but not to activate it).



- Move the cursor to any of the handles that appear until it changes to a double-headed arrow.



- Hold the left mouse button down and drag the cursor in the direction you want the component's dimensions to change.



- Let go of the mouse button.

To change a component back to its original size after stretching it:

- Click once on the component with the right mouse button.
- Choose **View** ⇒ **Original Size** from the context menu.

Adding and removing ports

When you place a component on a Worksheet, it will have a certain number of input ports and a certain number of output ports, either by default or according to what you specified in a Wizard. You can modify the number of ports on some components.

To add or remove ports:

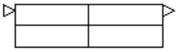
- Click on the component with the right mouse button.
- Choose **Add Input Port, Add Output Port**, **Remove Input Port**, or **Remove Output Port** from the context menu.

Flipping port direction

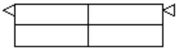
By default, any input ports a component has are located on the left side and any output ports are located on the right side. You can reverse these port directions. Reversing the port directions may reduce a system's apparent complexity by shortening the wire paths between connected components.

To flip the port direction of a component:

- Click once on the component with the right mouse button. The context menu appears.



- Choose **Flip Port Direction** from the context menu. The input and output ports on the component change direction, and any connecting wires adjust accordingly.



Note The **Flip Port Direction** menu item “toggles” the port direction. Selecting it again flips the ports back to their original orientation.

Deleting a component

To remove a component from the Worksheet:

- Click a component to select it.
- Press [`Del`].

Deleting multiple components

To delete multiple components:

- Position the mouse pointer outside the components you want to delete.
- Hold the left mouse button down and drag a box around all the components you want to delete.
- Release the mouse button.
- Press [`Del`].

Copying, cutting, and pasting components

To copy or cut a component from a Worksheet:

- Click on a component to select it, or select a group of components by holding the left mouse button down and dragging over all the components you want to select.
- Click 📄 or ✂ on the Toolbar or choose **Copy** or **Cut** from the **Edit** menu to copy or cut the component to the Clipboard.
- Click on any blank area of the Worksheet.
- Click 📋 on the Toolbar or choose **Paste** from the **Edit** menu. A copy of the component(s) on the Clipboard is inserted at the upper left corner of the Worksheet.
- If necessary, move the copied component to another location in the Worksheet.

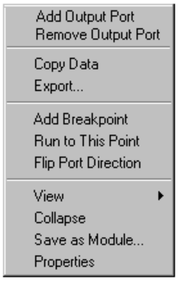
Configuring the components

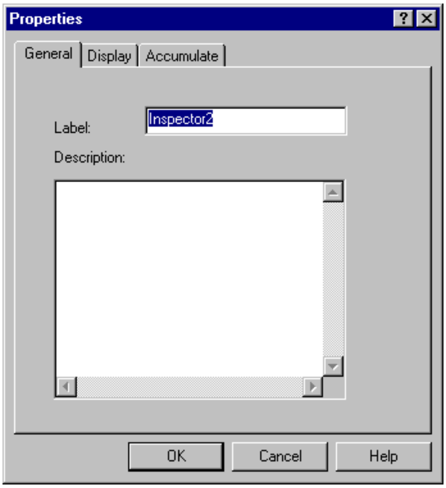
After inserting components into a Worksheet, you should configure each component so that it knows what to do with the input and what to send as output. To do so, you use the Properties dialog for the component, apply other commands from the component's context menu, or enter values or equations directly into the component.

Using the Properties dialog

Some components, such as the Mathcad component, bring up Setup Wizards when you place them on a Worksheet, so you will already have done some configuration when you insert them. When using other components, however, you need to use the Properties dialog box to specify the component's behavior. To do so:

- Click once on a component with the right (or second) mouse button. A context menu appears. For example, click on the Inspector component to see the context menu shown at right:
- Choose **Properties**. You'll see the tabbed dialog box shown below:





Label: Inspector2

Description:

Many options which control the behavior of a component are available in this dialog. Each component has a General tab showing the component's label—the name that appears below the component—and a brief description, if you choose, of what the component does.

- Since this Inspector component in our example will be displaying the coefficients Mathcad calculates, rename it “Coefficients” by typing **Coefficients** in the Label text box.

- Click “OK.”

Try relabeling the other components in the system using the General tab in the Properties dialog of each component:

- Label the other Inspector component **R-squared**.

- Label the Mathcad component **Curve fit**.

- Label the Input component **Data**.

The other tabs in the Properties dialog differ for each component. For information on the options for a particular component, see Chapter 4, “Components.” For example, to find out more about the options in the Display and Accumulate tabs for the Inspector component’s Properties dialog, see the section “Inspector” on page 53.

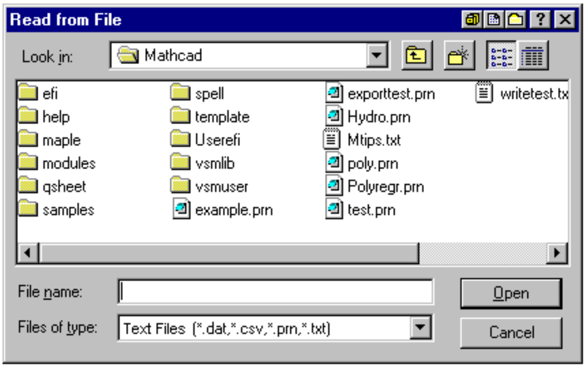
Using other options from the context menu

The **Properties** command from a component’s context menu is one way to control how it is going to behave or look in a system. Other commands on the context menu control other characteristics of a component’s behavior.

In our example, we need to import data from a data file into the Input component. To do that, we need to use the **Import** command from the Input component’s context menu.

- Click on the Input component with the right mouse button to see the component’s context menu.

- Choose **Import**. You’ll see the Read From File dialog box:



Look in: Mathcad

File name:

Files of type: Text Files (*.dat,*.csv,*.prn,*.txt)

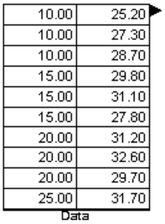
This dialog box lets you specify the name and type of file to import. For this example, we will import a Microsoft Excel data file.

- Choose **Excel Files** from the list in the “Files of Type” drop down list.

- Browse to the file **crvdata.xls** located in the **Samples** folder.

- Click “Open.”

The cells of the Input component will be filled with data values for our curvefitting. The first column contains the *x* values and the second column contains the *y* values.



10.00	25.20
10.00	27.30
10.00	28.70
15.00	29.80
15.00	31.10
15.00	27.80
20.00	31.20
20.00	32.60
20.00	29.70
25.00	31.70

Data

Activating a component

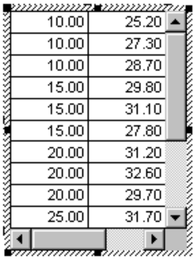
To type equations or values into a component, to resize it, or to scroll through it, you first need to double-click on it to activate it. Some components activate in-place: the MathConnex menus and tool bars will change to those specific to the component, and scroll bars and handles appear on the edges of the component.

For example, to activate the Input component, double-click on it.

You'll see:

- Scroll bars for scrolling around the values in the component.
- Handles for resizing.

You'll also have access to the cells in the table.



10.00	25.20
10.00	27.30
10.00	28.70
15.00	29.80
15.00	31.10
15.00	27.80
20.00	31.20
20.00	32.60
20.00	29.70
25.00	31.70

Other components, and components displayed as icons, activate in a separate window rather than in place. For example, to activate the Mathcad component:

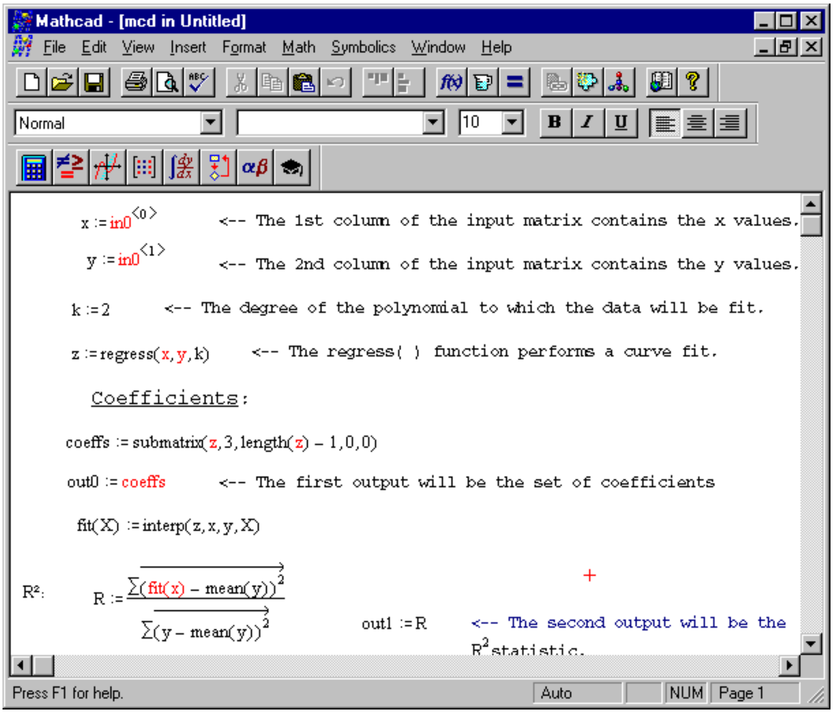
- Double-click on it.

You'll see a Mathcad window containing the Mathcad worksheet and giving you access to the equations in it. Figure 3-1 shows an example.

Here you can see that:

- The curve fit is performed by the Mathcad *regress* function.
- The data going into Mathcad is passed to the Mathcad variable **`in0`** and the outputs are values from the Mathcad variables **`out0`** and **`out1`**. These names are always associated with the inputs and outputs of a Mathcad component. See the section "Mathcad" on page 60 for more information.

Note Since the Mathcad component is displayed as an icon in this example, double-clicking on it brings up a separate window. If the component were displayed as a Mathcad worksheet, however, double-clicking on it would make it activate in place: the MathConnex menus and tool bars would be replaced with those of Mathcad.


Mathcad - [mcd in Untitled]
File Edit View Insert Format Math Symbolics Window Help
Normal
10
B I U
Press F1 for help.
Auto
NUM
Page 1

$x := in0^{\langle 0 \rangle}$ <-- The 1st column of the input matrix contains the x values.

$y := in0^{\langle 1 \rangle}$ <-- The 2nd column of the input matrix contains the y values.

$k := 2$ <-- The degree of the polynomial to which the data will be fit.

$z := regress(x, y, k)$ <-- The regress( ) function performs a curve fit.

Coefficients:

$coeffs := submatrix(z, 3, length(z) - 1, 0, 0)$

$out0 := coeffs$ <-- The first output will be the set of coefficients

$fit(X) := interp(z, x, y, X)$

R²: $R := \frac{\sum \overrightarrow{(fit(x) - mean(y))^2}}{\sum \overrightarrow{(y - mean(y))^2}}$ $out1 := R$ <-- The second output will be the R^2 statistic.

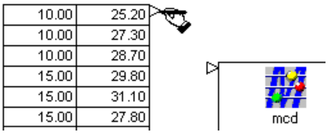
Figure 3-1: Double-clicking on the Mathcad component icon activates a full Mathcad window.

Wiring components together

Once you've placed two or more components on your Worksheet and configured them, you can wire them together so that the data flows from one to the next. See Figure 3-2 for an example.

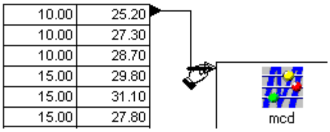
To wire two components together:

- Position the pointer over the output port from one component until it changes to a ☜.



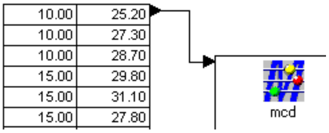
10.00	25.20
10.00	27.30
10.00	28.70
15.00	29.80
15.00	31.10
15.00	27.80

- Click and hold the left mouse button and drag to the input port of another component.



10.00	25.20
10.00	27.30
10.00	28.70
15.00	29.80
15.00	31.10
15.00	27.80

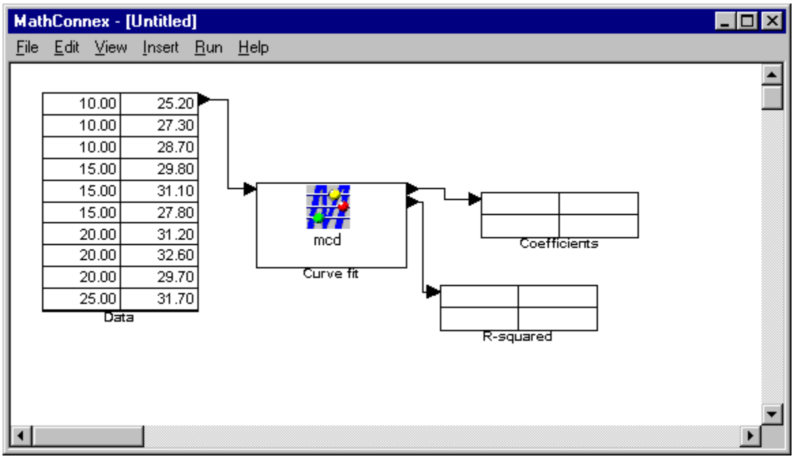
- When the pointer changes to a ☞, release the mouse button. The connected input and output ports will now have a black interior rather than a white one.



10.00	25.20
10.00	27.30
10.00	28.70
15.00	29.80
15.00	31.10
15.00	27.80

Note You can connect wires either from–to or to–from components. You can also connect multiple wires from one output port, but only one wire can enter an input port.

You can connect the output ports of the Mathcad component to the input ports of the Inspector components so that you have a system that looks like Figure 3-2.



10.00	25.20
10.00	27.30
10.00	28.70
15.00	29.80
15.00	31.10
15.00	27.80
20.00	31.20
20.00	32.60
20.00	29.70
25.00	31.70

Figure 3-2: A completed curve fitting system. The Mathcad component calculates a polynomial fit for the data and outputs the coefficients and the value of R-squared.

Disconnecting components

If you need to disconnect two components:

- Move the pointer over the component's input port to which a wire is attached.
- The pointer changes to ☞.
- Click the left mouse button and hold it down while moving to an empty area.
- When the pointer changes to a crosshair, release the mouse button. The wire disappears.

Note A wire can be disconnected from an input port only. Trying to grab and drag the wire from an output port creates another wire.

Tip If you disconnect a wire by mistake, choose **Undo** from the **Edit** menu or press [`Ctrl`]`Z` to reconnect the wire.

Running and stopping a system

After placing a group of components on a Worksheet and connecting them, you can make data flow from one to the next by running the system.

The basics

To run a system:

- Choose **Run** from the **Run** menu or press ▶ on the toolbar.

When you run a system, data flows from one component to the next until the system is stopped. Even if data has reached its final destination, a system will keep running until it is stopped. For more information on the run model MathConnex follows, see Chapter 5, “Advanced Topics.”

To stop data from flowing through the system, you can:

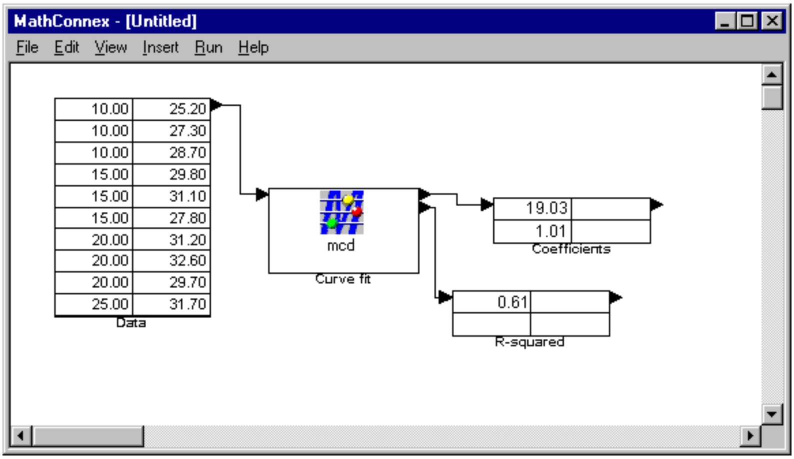
- Choose **Stop** from the **Run** menu
- Press the 🟥 button on the toolbar
- Place a Stop/Pause component at the end of a system

Placing a Stop/Pause component at the end of a system is generally the best way to stop a system. The Stop/Pause component eliminates the need to stop a system manually each time it runs.

For more information on the Stop/Pause component, see the section “Components for controlling data flow” in Chapter 4.

Note Until you stop a system, you are unable to edit your project or drag components from the palettes.

Figure 3-3 shows a system that ran and was stopped using the **Stop** command. Data passed from the Input component to the Mathcad component. The Mathcad component calculated the curve fit and passed the coefficients to one Inspector component and the value of R-squared to the other.



Data	
10.00	25.20
10.00	27.30
10.00	28.70
15.00	29.80
15.00	31.10
15.00	27.80
20.00	31.20
20.00	32.60
20.00	29.70
25.00	31.70

Coefficients	
19.03	
1.01	

R-squared	
0.61	

Figure 3-3: Running a completed curve-fitting system. Choose ***Run*** *and then* ***Stop*** *from the* ***Run*** *menu.*

Highlighting active components

As data flows into a component, it starts processing. If you want to see which components are processing as the data flows through a system:

- Choose **Highlight Components** from the **Run** menu.
- Run the system.

As each component becomes active, its border turns green.

Stepping through a system

If you want to see a system run component by component, you can step through a system. To do so:

- Choose **Highlight Components** from the **Run** menu.
- Choose **Step** repeatedly from the **Run** menu or continually press the button in the Toolbar.

The system will run through one component at a time, and the borders of the currently active components will be highlighted in green.

When you step through the curve-fitting system shown in Figure 3-2, you'll see that first the Constant component is active, then the Mathcad component, and then the two Inspector components.

In this case, it is easy to determine the order in which the components become active. In a more complicated example, however, a system can branch when a component can send output to more than one component. In a more complex system such as this, the **Highlight Components** option is especially helpful.

Pausing a running system

To stop a running system temporarily:

- Press the ⏸ button in the Toolbar, or choose **Pause** from the **Run** menu, while the system is running.
- The system will stop until you resume running by clicking ▶ or ⏯ in the Toolbar.

Note You can also pause a system by placing a Stop/Pause component in it. For more information on the Stop/Pause component, see the section “Components for controlling data flow” in Chapter 4.

Tip While the system is paused, you can view input data on the wires using the magnifying glass. See “Inspecting values as they pass through the system” on page 39 for more information.

Breakpoints

Adding a breakpoint to your system allows you to analyze your system by examining the values at a prespecified point in the system rather than pausing the system at a random spot. You can add and remove breakpoints to individual components or to all the components in a system.

Adding breakpoints

To add a breakpoint to a component:

- Click on the component with the right mouse button to display the component’s context menu.
- Choose **Add Breakpoint** from the context menu. The component becomes outlined in red.
- Run the system.

The component’s border turns yellow each time the breakpoint is reached when you run the system.

Clicking the ⏯ or ▶ button on the Toolbar after the temporary breakpoint has been triggered continues execution and removes the temporary breakpoint.

To add a breakpoint to all the components in a system:

- Click in a blank spot of the Worksheet with the right mouse button to display a context menu.
- Choose **Set All Breakpoints** from the context menu. All the components become outlined in red.

Removing breakpoints

To eliminate a breakpoint on a component:

- Click on the component with the right mouse button to display the component’s context menu.
- Choose **Remove Breakpoint** from the context menu. The red outline disappears.

To remove all the breakpoints in a system at once:

- Click in a blank spot of the Worksheet with the right mouse button to display a context menu.
- Choose **Remove All Breakpoints** from the context menu. The red outline on all components disappears.

Running to a certain point

To run a system up to a certain component in the Worksheet:

- Click on the component with the right mouse button to see the component’s context menu.
- Choose **Run to This Point** from the context menu. The component is outlined in red.

The system automatically runs until it reaches the component. At this point, execution pauses and the component's border turns green.

You can resume running the Worksheet by clicking the ▶❙ or ▶ button on the Toolbar.

Inspecting values as they pass through the system

As a system is running, you can see what values are on a wire—either out of an output port or into an input port. To do so:

- Choose **Pause** from the **Run** menu.
- Let the mouse pointer hover over a component’s output port until it changes to a 🔍. The value being passed out of the component appears.
- Move the pointer over a component’s input port to see the value being passed into the component.
- If the value being passed is a vector or matrix, click with the left mouse button while the 🔍 is showing to see a tabular display of the vector or matrix.

Changing the appearance of components

When you place a component on a Worksheet, it has a certain default appearance. For example, the Inspector component by default shows a 2×2 spreadsheet-like table.

In some systems, you may want to minimize the amount of space a component takes up or otherwise alter the appearance of a component. You can change the way a component looks in a MathConnex Worksheet by resizing the component, displaying it as an icon, or displaying another object in place of it.

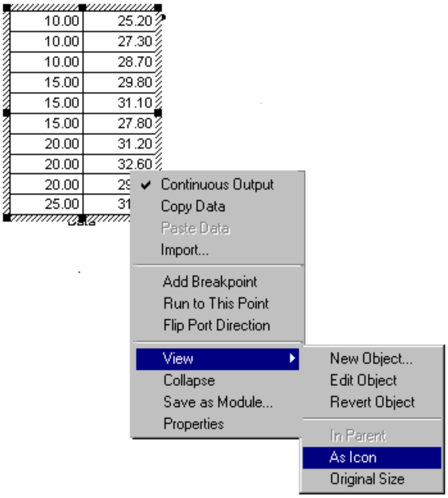
When you change the appearance of a component, keep in mind that you are affecting only the image of the component you see in the Worksheet. You are not affecting the component's properties or the number of input and output ports. The component will behave as it did before you changed its appearance. You can also manipulate the component's properties and functionality just as you did before.

Displaying a component as an icon

By default, some components are designed to show calculations or certain property settings when they are inserted. For example, the Conditional component defaults to displaying all the conditional statements. In some cases, the display of the statements may make a system look cumbersome or needlessly complicated.

One way to hide the calculations or statements behind a component is to display the component as an icon. For example, to hide the data in the curve fitting system shown in Figure 3-2, you can display the Input component as an icon:

- Click on the component with the right mouse button to bring up its context menu.
- Choose **View** ⇒ **As Icon** so that it is checked. You'll see a default icon that is similar to the component's icon in the Component Palettes.



10.00	25.20
10.00	27.30
10.00	28.70
15.00	29.80
15.00	31.10
15.00	27.80
20.00	31.20
20.00	32.60
20.00	29
25.00	31

If later you want to display the component in its default form again:

- Click on the component with the right mouse button to bring up its context menu.
- Choose **View** ⇒ **As Icon** so that it is no longer checked.

Displaying a component as another object

In some cases, you may want the appearance of a component to indicate the component's behavior. For example, a component that simulates a circuit's behavior could show a diagram of the corresponding circuit. In this case, a diagram would be clearer than the component's default appearance or an icon. MathConnex therefore lets you view a component as some other object that's more appropriate.

In the sample system shown in Figure 3-3, the Input component provides data on the compressive strength of an alloy at various concentrations of an additive. Instead of displaying the actual data or an icon, a better idea might be to display a picture of the alloy involved or the instruments used to gather the data.

To do so:

- Click on the component with the right mouse button to bring up its context menu.
- Choose **View** ⇒ **New Object**.
- Choose an appropriate object in the Insert Object dialog box. For example, to create a new picture, select Bitmap Image to bring up Paint or another drawing application. If the application supports in-place activation, you'll see the MathConnex menus and toolbars change to the other application's menus and toolbars.
- Create the new object. When you are finished, click away from the component.

The component's appearance will change to that of the object you created.

Once you create this object, you can edit it whenever you need to. In the example described above, for instance, you may want to improve your drawing or add color.

To edit the object:

- Click on the component with the right mouse button to bring up its context menu.
- Choose **View** ⇒ **Edit Object**. The object activates in place or inside the application that created it.
- Make the necessary changes.
- Click away from the component to resume working in MathConnex.

If, after viewing a component as an object, you want view it in its default form:

- Click on the component with the right mouse button.
- Choose **View** ⇒ **Revert Object** from the context menu.

Labeling a component

By default, when you place a component on a Worksheet, it displays a label at the bottom. The label indicates the type of component it is and the order in which you placed it on the Worksheet.

You can force MathConnex to hide all labels or you can change a component's label to something more appropriate for your system. For example,"Using the Properties dialog" on page 31 describes how to change the label of the Mathcad component to "Curvefit" instead of "Mathcad1" because the equations in the Mathcad component were performing a polynomial fit.

To change the label of a component:

- Click on the component with the right mouse button to bring up the context menu.
- Choose **Properties**.
- In the General tab, type a new label in the Label text box.
- Click “OK.”

To hide the labels of all components in the system:

- Choose **Show Labels** from the **View** menu to remove the check mark next to it.

Chapter 4
Components

Every project you create in MathConnex consists of components, usually wired together to form a system. This chapter describes the basic MathConnex components in detail, explaining how each component generates or manipulates data and revealing situations in which you might use it.

Overview

General description of components, how to insert them into a Worksheet, and how to prepare them to pass data through a system.

Components for generating, importing, and exporting data

Using the Input component to type in data or import it from a file. Using the File Read/Write component to dynamically read from or write to a data file. Using the Ramp component to generate a series of data points. Using the Global Variable component to give a name to a set of data.

Components for viewing results

Using the Inspector component to view data in a table. Using the Graph component and the Axum component to plot data.

Computational components

Using the Mathcad, Excel, MATLAB, and ConnexScript components to manipulate data mathematically.

Components for controlling data flow

Using the Conditional component to send data based on whether a conditional statement is true or false. Using the Initialize component to get data from one input port for the first execution and another port for all subsequent executions. Using the Stop/Pause component to halt a running system. Using the Wire Breaker component to prevent data flow from one component to another.

Other components

Using the Text component to annotate a project and describe a system. Introduction to the Scripted Object component for scripting an OLE object.

Overview

MathConnex lets you design systems of applications and data sources where each application and data source is a *component* in the system. A MathConnex Worksheet is therefore made up of various components connected to each other so that data flows from one component to the next. When data is flowing into a component, it is considered *input* to that component. Data coming out of a component is *output*.

Each component in the system does something different with the data. Some components generate the data, others manipulate it as it passes through, and some components simply display the data or direct the data flow more precisely.

To create a system you should first determine which components you'd like to use in the system. Then you should:

- Insert the necessary components onto a MathConnex Worksheet.
- Configure each component so that it knows what do with the input and what to send as output.
- Wire the components together, connecting the output port(s) of one component to the input port(s) of another.
- Run the system.

Although the details of these steps differ slightly for every system you create, the sections which follow will introduce you to the components so that you know what they do, how to insert them, and how to configure them. See Chapter 3, "Creating and Running a System," for information on wiring components and running the system.

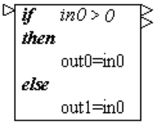
Inserting a component

In general, to insert one of the basic components into a MathConnex Worksheet:

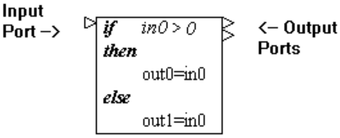
- Click on a component icon from the Component Palettes.
- Hold the mouse button down and drag the component to the Worksheet.
- Let go of the mouse button.

Depending on the component you choose, you may see a Wizard dialog box which lets you specify some properties of the component before it is inserted. Pressing the "Next" buttons continues through the Wizard. You can use the "Back" buttons to go back to a previous page. When you click the "Finish" button, the component is inserted into your Worksheet.

If you don't see a Wizard when you drag one of the components onto the Worksheet, you'll immediately see the component, with some default properties, inserted into your Worksheet. For example, when you drag the ? icon to the Worksheet, you'll see the Conditional component:



Each component has its own appearance, so you will see something different for each component you choose. Each component has input ports and/or output ports which allow input to flow in and/or output to flow out of the component:



An input port allows data to pass into a component. An output port lets a component send data out. Some components have a fixed number of input ports and output ports, while other components can have up to four input ports and/or output ports. To add or remove input or output ports:

- Click on the component with the right mouse button to bring up the component's context menu.
- Choose **Add Input Port**, **Remove Input Port**, **Add Output Port**, or **Remove Output Port**.

Tip You can also insert a component by choosing **Component** from the **Insert** menu and selecting a component from the list in the Wizard.

Controlling how a component looks in the Worksheet

Although each component has a default appearance, you can display some of the components as icons instead.

To display a component as an icon:

- Click on the component once to select it.
- Click on it with the right mouse button to see a context menu.
- Choose **View** ⇒ **As Icon** so that **As Icon** is checked.

The component will appear as an icon in the Worksheet but will maintain its functionality. This is useful when you don't need to see the details of a component's behavior. For example, if you do not want to see all the Excel values stored in an Excel component, you can view it as an icon.

By default, when you place a component on a Worksheet, it has a label at the bottom. The label indicates the type of component it is and the order in which you placed it on the Worksheet.

You can force MathConnex to hide these labels or you can change the label to something more appropriate for your system. To change the label of a component:

- Right-click on the component to bring up the context menu.
- Choose **Properties**.
- In the General tab, type a new label in the Label text box.

To hide the component labels:

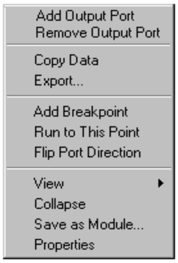
- Choose **Show Labels** from the **View** menu to remove the check mark next to it.

For more information on changing the appearance of a component by viewing it as another OLE object, see the section “Changing the appearance of components” in Chapter 3.

Configuring a component

Once you’ve inserted a component into a Worksheet, you usually need to set up the component’s properties so that the component knows how to handle any inputs it’s getting from other components and what to send as output. To configure the properties for a component:

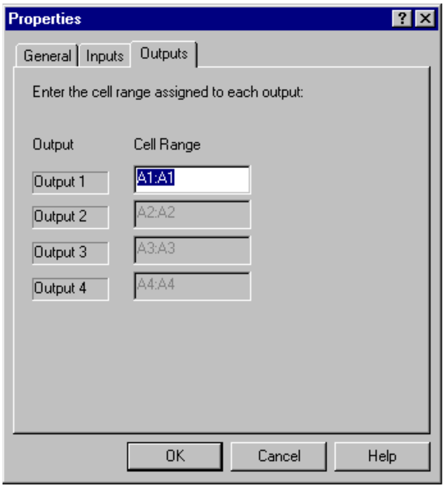
- Click on the component once to select it.
- Click on it with the right mouse button to bring up a context menu, like the one shown here for the Inspector component.



Tip To see the context menu for any component, the component must not be activated. You can deactivate a component by clicking in a blank spot of the Worksheet.

- Choose **Properties** from the context menu.

The Properties dialog box for the component appears.



Enter the cell range assigned to each output:

Output	Cell Range
Output 1	A1:A1
Output 2	A2:A2
Output 3	A3:A3
Output 4	A4:A4

The settings in the Properties dialog box differ for each component. For example, the properties dialog for the Excel component (shown above) lets you specify the cells in which the input values are stored and the cells from which the output is sent.

Final steps

Once you insert and configure a group of components on a Worksheet in MathConnex, you can wire them together and run the system. Refer to Chapter 3, “Creating and Running a System,” for more information on connecting components and running a system.

Components for generating, importing, and exporting data

Some components in MathConnex are useful for bringing data into or out of a system. A component that introduces data into a system might be used first in a system. Components which export data out to a data file or to the Clipboard are useful whenever you need to capture the results for later use.

When introducing data to a system, you should consider where the data is stored.

- If your data is stored in a data file, you can use the Input component or the File Read/Write component to read it into MathConnex.
- If you need to type in your data or import it from the Clipboard, use the Input component.
- Use the Ramp component to generate a series of data values.
- The File Read/Write component can dynamically write data to a variety of data file types.
- The Global Variable component is useful for referring to some data produced anywhere in the system so you don’t have to connect to the actual component producing it.

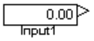
Input

Using the Input component you can:

- Type data in manually so it can be used in a system.
- Import data from a data file.
- Paste in data from the Clipboard.

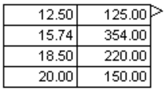
To place the Input component on your Worksheet:

- Drag the 1.0 icon from the Component Palettes to your Worksheet. The Input component appears.



- You can then type values into the cells, import values from a data file, or paste them in from the Clipboard.

Once you’ve done so, the Input component might look like this:



12.50	125.00
15.74	354.00
18.50	220.00
20.00	150.00

Typing in values

To enter values into the Input component:

- Double click on the component.
- If necessary, you can show more cells by clicking on one of the handles, holding the mouse button down, and dragging out.
- Enter values into the cells. Pressing [`Enter`] will bring you to the next cell down. You can enter any kind of decimal or e-format number such as 3.4 or 2i or 4e-6.

Tip If you don’t double-click once on the component before using the handles to enlarge the component, you’ll simply stretch the component rather than enlarge the view.

If you type any imaginary or complex values, all the values in the component will be displayed as complex values. For example, if you type **`4`** in one cell and **`6i`** in another cell, the values will display as **`4.00 + 0.00i`** and **`0.00 + 6.00i`**.

Importing values from a data file

To import data from an external data file after placing the Input component on a Worksheet:

- Click once on the component with the right mouse button.
- Choose **Import** from the context menu. The Read from File dialog box appears.
- In the “Files of Type” text box, choose the type of file from which you want to import data.
- Use the dialog box to browse to the data file and click “Open.”

Note You can choose to import the following types of files: ASCII Text, MATLAB, Excel, Lotus 1-2-3, Quattro Pro, dBase III, and S-Plus.

Pasting in data from the Clipboard

If your data is stored in another application, but not in a saved file, you can copy it to the Clipboard and paste it into the Input component. To do so:

- Select the data in the other application and copy it to the Clipboard. In most applications, you do this by choosing **Copy** from the **Edit** menu.
- Place the Input component on a MathConnex Worksheet.
- Click on it with the right mouse button so that a context menu appears.
- Choose **Paste Data** from the context menu.

Controlling the format of the values in the Input component

To control the way the numbers in the Input Component are displayed:

- Click once on the component to select it.

- Click on the component with the right mouse button so that you see the context menu.
- Choose **Properties** from the context menu.
- Click on the Display tab.
- Enter the settings you want and click “OK.”

The settings on the Display tab are as follows:

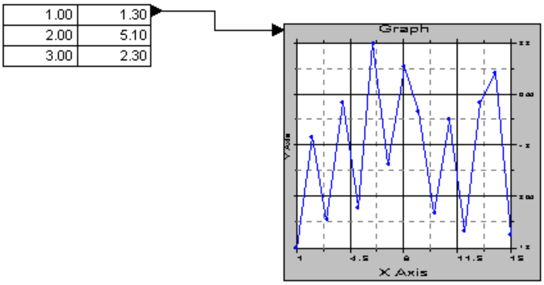
Displayed Precision: Choose or type an integer *n*. Determines the number of values to the right of the decimal place.

Exponential Threshold: Choose or type an integer *n*. Values smaller than 10^{-n} or greater than 10^{n} are displayed in exponential notation.

Zero Tolerance: Choose or type an integer *n*. Values smaller than 10^{-n} are displayed as zero.

Show index labels: Click this box to display the row and column numbers associated with the values in the table.

Tip Keep in mind that these settings only affect the display of numbers in the Input component. They do not affect the precision of values sent from the component as output.



1.00	1.30
2.00	5.10
3.00	2.30

Figure 4-1: The Input component provides data for a system.

Editing the Input component

Once you’ve imported or typed values into the Input component, you can edit them. First, double-click on the component to activate it and then click on whichever cells you want to edit.

To delete a row or column of cells:

- Double-click on the Input component to activate it.
- Click in a cell in the row or column to delete.
- Click on the cell with the right mouse button to display a context menu.
- Choose **Delete Cells** to bring up the Delete dialog box.
- Click either Entire Row or Entire Column and click “OK.”

To insert a row or column of cells:

- Double-click on the Input component to activate it.
- Click in a cell in the row to the left of where the new row or column will be inserted.
- Click on the cell with the right mouse button to display a context menu.
- Choose **Insert Cells** to bring up the Insert dialog box.
- Click either Row or Column and click “OK.”

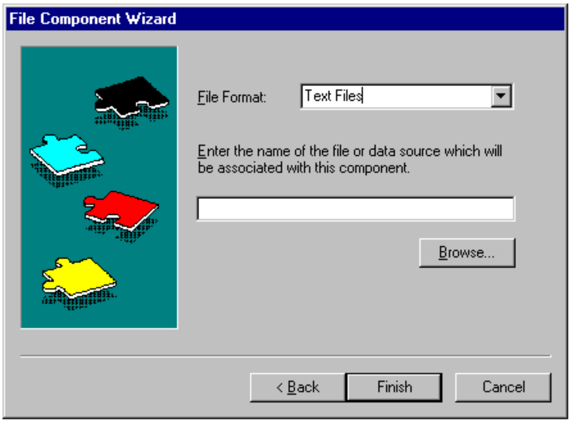
File Read/Write

Using the File Read/Write component you can:

- Establish a live connection to a data file.
- Read data from the file or write data to it.

To place the File Read/Write component on your Worksheet:

- Drag the icon from the Component Palettes to your Worksheet. The first part of the Setup Wizard appears.
- Choose “Read from data source” if you want to read in data from a file. Choose “Write to a data source” to write to a data file.
- Press “Next” to go to the second page of the Wizard, shown below.



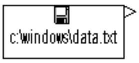
File Component Wizard

File Format: Text Files

Enter the name of the file or data source which will be associated with this component.

- From the drop-down list in the File Source box, choose the type of data file you want to read from or write to.
- Type the path to the data file you want to read or use the “Browse” button to locate it.
- Press “Finish.”

You’ll see the File Read/Write component and the path to the data file. For example, if you read from a data file called **`data.txt`**, you’ll see:



Note You can choose to read from or write to the following types of files: ASCII Text, MATLAB, Excel, Lotus 1-2-3, Quattro Pro, dBase III, and S-Plus.

When you run a system containing the File Read/Write component, data will be read in from or written to the data file every time the component is triggered.

When the File Read/Write component writes to a file, any data already existing in the file will be overwritten. If you don't want existing data to be overwritten, click on the component with the right mouse button and choose **Overwrite File** from the context menu. Then when the component is triggered, it will ask you whether you want to overwrite existing data.

When the File Read/Write component is reading from a file, it will read in the entire data file. To read in only certain rows or columns of a data file:

- Click once on the component with the right mouse button so that you see the context menu for the component.
- Choose **Properties** from the context menu to bring up the Properties dialog box.
- Click on the File Options tab and specify the row and columns at which to start and stop reading.

To change the data file or type that's being read from or written to:

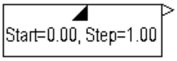
- Click with the right mouse button on the component and select **Choose File** from the component context menu.
- In the "Files of type" text box, choose a type of file. Use the dialog box to browse to the data file, select the data file, and click "Open."

Ramp

Use the Ramp component to generate a series of real scalar values and pass them into a system. This component is useful for problems which require iteration or incremental data.

To insert the Ramp component in a Worksheet:

- Drag the ◢ icon from the Component Palettes to your Worksheet. The Ramp component appears.



Start=0.00, Step=1.00

- Click on the component with the right mouse button and choose **Properties** from the context menu.
- Click on the Ramp tab and specify the starting value and the increment/step value.

When you connect the output port of the Ramp component to another component and run the system, the Ramp component generates one value at a time. The attached component will receive each value as it is produced. If one value isn't passed further along the system or if the attached component can't accept more than one value, the Ramp won't generate another value.

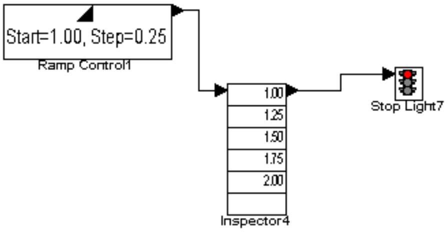


Figure 4-2: The Ramp component generates values. Here, several values accumulate in the Inspector component. See page 53 for more information on the Inspector component.

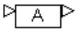
Global Variable

To use the output from one component in another, you have to connect the two components. If you want to send a single output to several different components, you have to connect the one component to several different components. This can involve a lot of wires and give a messy appearance to a MathConnex system.

An alternative to several connections and wires is to use the Global Variable component. The Global Variable component lets you give a name to the output from a component and refer to it without having to make a connection to the component producing it.

To give a name to some data using the Global Variable component:

- Drag the icon from the Component Palettes to your Worksheet. The Global Variable component appears.



- Click on the component with the right mouse button and choose **Properties** from the context menu.
- Click on the Variable Name tab and enter a name for the data. Make sure the box next to “This component sets the value” is checked.
- Connect the output port from the component generating the data to tag to the input port of the Global Variable.

When the system runs, the data going into the Global Variable will be tagged with the name you specified.

To refer to that data with its name via the Global Variable component:

- Place a Global Variable component on the Worksheet. By default, it will have the same variable name as the one you created previously.
- Connect the output port from the Global Variable component to any other component.

If you want to create a new Global Variable, follow the steps above, but replace the name in the Variable Name tab with a new name and click to place a check mark in the box next to “This component sets the value.”

When a Global Variable component receives values as input, all other Global Variable components with the same variable name send those values as output. To see this behavior, choose **Highlight Components** from the **Run** menu and press ▶| repeatedly.

The example below shows how one instance of a Global Variable gives a name to some output, and other instances refer to that output.

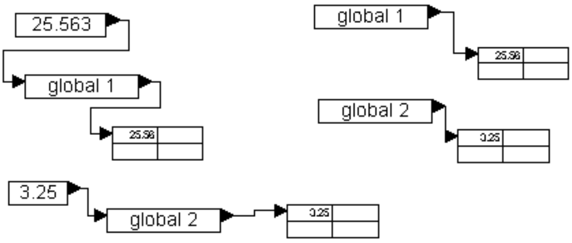


Figure 4-3: The names “Global 1” and “Global 2” are given to some data via the Global Variable component. Other instances of the Global Variable components with these names refer to the data.

Components for viewing results

As data travels from component to component along a wire in a MathConnex system, you can see what the data is at a certain point by either looking at it in a table or in a graph. To look at the data in a table, use the Inspector component. If you want to visualize the data in a graph, you can use the Graph component or the Axum component if you have Axum 5 installed.

Inspector

Using the Inspector component you can:

- Display the value of data on a wire in a spreadsheet format.
- Export the data being displayed to a data file.
- Accumulate data as it flows through a system.

To insert the Inspector component to the Worksheet:

- Drag the 👓 icon from the Component Palettes to your Worksheet. The Inspector component appears with a single input port.

When you connect the output port of another component to the Inspector component and run the system, the Inspector component displays the input and sends it along as output.

To see more values in the Inspector, double-click on it. You will see scroll bars which allow you to scroll through the Inspector. You will also see handles along the edges of the Inspector. To resize the table, move the cursor to one of these handles so that it changes to a double-headed arrow, press and hold down the mouse button, and drag the cursor in the direction you want the table's dimensions to change.

Tip If you don't double-click once on the component before using the handles to enlarge the component, you'll simply stretch the component rather than enlarge the view.

Adding output ports

By default, the Inspector component has one input port and no output ports. If you want to send output from the Inspector component, however, you can add a single output port. To do so:

- Click on the component with the right mouse button to bring up the context menu.
- Choose **Add Output Port**.

If you want to remove the output port later, choose **Remove Output Port** from the context menu.

Controlling the format of the values in the Inspector

To control the way the numbers in the Inspector are displayed:

- Click once on the component to select it.
- Click on the component with the right mouse button so that you see the context menu.
- Choose **Properties** from the context menu.
- Click on the Display tab, shown below.
- Enter the settings you want and click "OK."

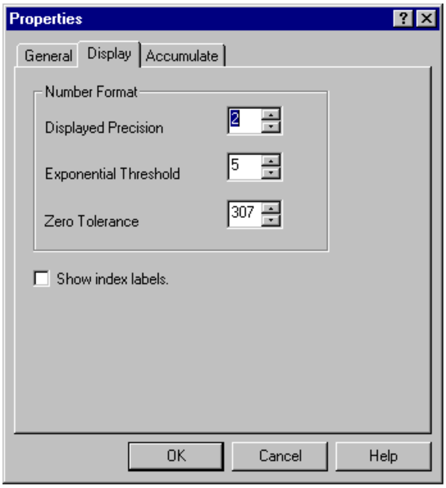
The settings on the Display tab are as follows:

Displayed Precision: Choose or type an integer *n*. Determines the number of values to the right of the decimal place.

Exponential Threshold: Choose or type an integer *n*. Values smaller than 10^{-n} or greater than 10^{n} are displayed in exponential notation.

Zero Tolerance: Choose or type an integer *n*. Values smaller than 10^{-n} are displayed as zero.

Show index labels: Click this box to display the row and column numbers associated with the values in the table.



Number Format

Displayed Precision 2

Exponential Threshold 5

Zero Tolerance 307

□ Show index labels.

Keep in mind that these settings only affect the display of numbers in the Inspector component. They do not affect the values sent from the component as output. The values are always sent using the maximum values for each setting.

Exporting to a data file

You can export the values you see in the Inspector to a data file. To do so:

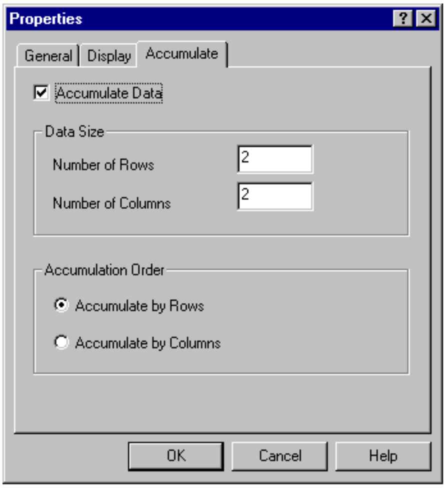
- Click on the Inspector component with the right mouse button so that you see the component's context menu.
- Choose **Export**. You will see the Write to File dialog box.
- In the "Files of type" text box, select the format of the file you'd like to create. Use the dialog box to browse to the folder in which the data file will be created and enter the name of the data file you wish to create. Then click "Open."

Note You can choose to export data to the following types of files: Formatted Text, Tab Delimited Text, Comma Separated Values, MATLAB, Excel, Lotus 1-2-3, Quattro Pro, dBase III, and S-Plus.

Accumulating data

The Inspector is also useful for storing data as it flows through the system. For example, you might want to run a system 15 times, capturing a value from each run. Then, once you've gathered 15 values, you want to send them further along the system. To gather values this way:

- Click on the Inspector component with the right mouse button.
- Choose **Properties** from the context menu.
- Click on the Accumulate tab.



Properties

General | Display | Accumulate

☑ Accumulate Data

Data Size

Number of Rows: 2

Number of Columns: 2

Accumulation Order

● Accumulate by Rows

○ Accumulate by Columns

- Click on the box next to Accumulate Data so that a check appears.
- Specify the total number of rows and columns of data values you'd like to accumulate and whether the values should accumulate row by row or column by column.

When the Inspector is configured to accumulate data, it will have one input port and one output port. It accumulates the number of values you specified in terms of rows and columns and then sends the values along the wire connected to the output port.

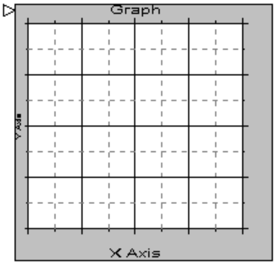
Figure 4-2 on page 52 shows an example in which the Inspector component is set to accumulate 5 rows and 1 column of data generated from the Ramp component.

Graph

The Graph component allows you to create a two-dimensional graph in a system. It accepts one or more pairs of *x* and *y* coordinates as input and graphs them.

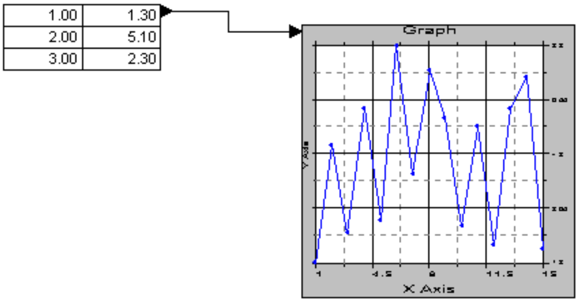
To place the Graph component on your Worksheet:

- Drag the icon from the Component Palettes to your Worksheet. The Graph component appears.
- Connect the output port of a component that is outputting coordinate pairs to the input port of the Graph component.



When you run the system, the Graph component creates a plot. This allows you to plot a group of data points or one data point at a time if the data are being passed as single values through the system.

Note The data passed to the Graph component must be stored in $n \times 2$ form, where each of the rows contains an ordered pair *x*,*y*. See Figure 4-4 for an example.



1.00	1.30
2.00	5.10
3.00	2.30

Figure 4-4: The Graph component plots rows containing x,y coordinate pairs.

Controlling plot properties

To control specifics about the graph such as which input values to graph and whether there are labels or tick marks:

- Click on the component with the right mouse button.
- Choose **Properties** from the context menu.

Use the Plot, Labels, and Axes tabs to control the look of the graph:

- Click on the Plot tab to control data history (how often to reset the graph), colors, and style settings such as line and symbol types.
- Click on the Labels tab to specify the axis labels, title, and legend used on the graph.
- Click on the Axes tab to control whether the Axes are boxed or crossed in the lower right corner and to specify scales, ranges, and whether tick marks or grid lines will appear.

Note To make changes in the Axes tab for either the *x* or *y* axis, choose either x-axis or y-axis in the “Assign Settings For” box.

For more information on the various options in each tabbed page of the Properties dialog box, click the “Help” button in the dialog box.

Tip You can save your customized graph settings by saving the custom graph as a module. Fonts and plot characteristics are stored in the module and can be easily dropped into other Worksheets. See the section “The MathConnex Explorer” in Chapter 2 for more information about modules.

Copying the Graph component

To copy a Graph component to the Clipboard:

- Click on the component with the right mouse button to display the component’s context menu.
- Click **Copy to the Clipboard** in the context menu.

The graph will be copied to the Clipboard as an enhanced metafile. When you open another application that supports the enhanced metafile format (EMF), you can paste the copied graph into that application.

Adding output ports

By default, the Graph component has one input port and no output ports. If you want to send output from the Graph component, however, you can add a single output port. To do so:

- Click on the component with the right mouse button to bring up the context menu.
- Choose **Add Output Port**.

If you want to remove the output port later, choose **Remove Output Port** from the context menu.

Axum

Axum is a technical graphing and data analysis application available from MathSoft. If you have Axum 5 installed on your system, the Axum component gives you access to a variety of two and three-dimensional graph types.

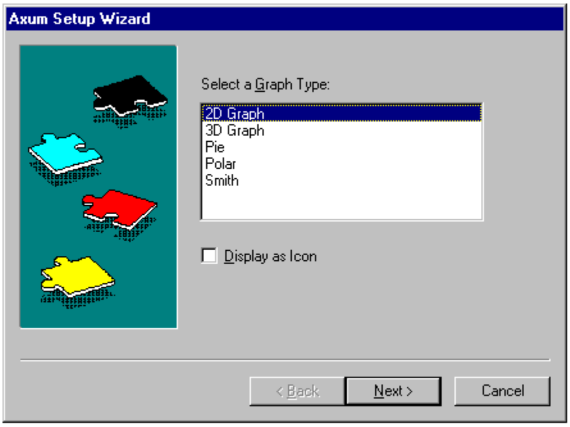
Using the Axum component you can:

- Create over 75 different types of 2D and 3D graphs.
- Double-click on the Axum component to activate Axum to format every detail of your graph.

Tip When an Axum component is activated, Axum will run in the background. You will therefore need enough available memory to run Axum and MathConnex simultaneously.

To place an Axum component on your Worksheet:

- Make sure Axum 5 is installed (but not necessarily running) on your system.
- Drag the icon from the Component Palettes to your Worksheet. This launches the first part of the Axum Setup Wizard.



- Choose the type of graph you would like to insert and click “Next.”
- Choose a plot type. The available choices depend on the type of graph you selected.

- Click “Finish.”

An Axum graph of the type you specified is inserted into your Worksheet with an appropriate number of input ports. There are no output ports because the Axum component does not send output.

When you connect a component to the Axum component and run the system, the input data is plotted. See Figure 4-5 for an example.

Note The form of the data you pass into the Axum component depends on the kind of graph you want to create. See the *Axum User’s Guide* or on-line Help to find out what form the data should be provided in for a given plot type.

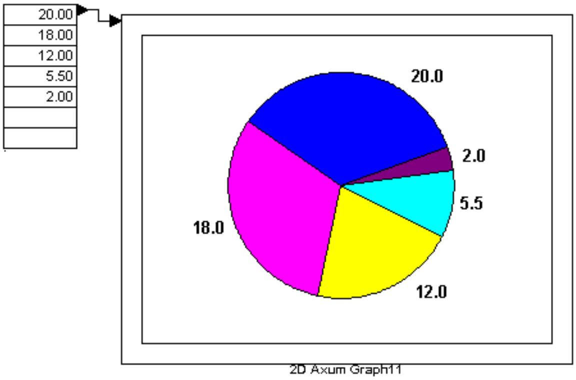


Figure 4-5: The Axum component lets you place a variety of 2D and 3D graphs in a MathConnex system.

Editing the Axum component

You can change the format of a graph that you created using the Axum component using Axum features. For example, you can change the colors in the graph, the labeling, whether there are grid lines, etc.

To edit the Axum component:

- Double-click on the Axum component in your Worksheet to activate Axum. The menus and toolbars in MathConnex will change to Axum’s menu and toolbars.
- Format the graph using Axum commands and features. See the *Axum User’s Guide* or on-line Help for more information on editing graphs.

Tip If an Axum component is displayed as an icon and you double-click on it, the menus and toolbars in MathConnex won’t change to Axum’s, but a separate Axum window will appear.

Computational components

While some components introduce data into a system or display it in a table or graph, the following four components let you manipulate the data mathematically or in any other ways allowed by the component:

- Mathcad component
- Excel component
- MATLAB component
- ConnexScript component

For example, you might use Mathcad to perform linear regression on a set of data, or you might use the Excel component to exchange rows and columns of values.

Note To use either the Mathcad, Excel, or MATLAB component you must have the corresponding product installed on your system. Refer to the sections that follow for details.

Tip When a Mathcad, Excel, or MATLAB component is activated, the corresponding application will run in the background. You will therefore need enough available memory to run both the application and MathConnex simultaneously.

Mathcad

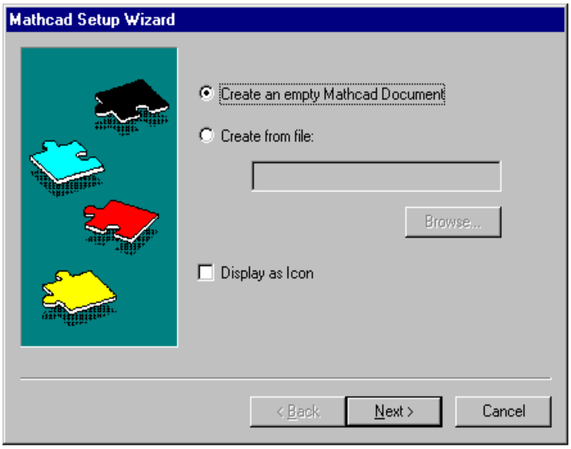
The Mathcad component lets you create or connect to a Mathcad worksheet and pass numerical data between a MathConnex system and a Mathcad worksheet.

When using the Mathcad component you can:

- Manipulate data using Mathcad functions and operators.
- Use a Mathcad worksheet as a data source for introducing data into a system.
- Display data in a Mathcad graph or surface plot.

To place the Mathcad component on your Worksheet:

- Make sure Mathcad 7 Professional is installed (but not necessarily running) on your system.
- Drag the icon from the Component Palettes to your Worksheet. This launches the first part of the Mathcad Setup Wizard:



Mathcad Setup Wizard

● Create an empty Mathcad Document

○ Create from file:

□ Display as Icon

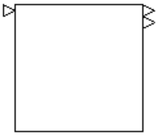
- If you want to connect to an existing Mathcad file, choose “Create from file,” and type the path name in the text box or use the Browse button to locate the file; then click “Open.” If you don’t want to connect to a previously created file, choose “Create an empty Mathcad worksheet.”

- Click the Display as Icon box if you want to display the Mathcad component as an icon in the Worksheet rather than as a view onto a Mathcad worksheet.

Tip Although you won’t see the Mathcad equations in the component when you display it as an icon, you can double-click on the component to edit it, and a separate, moderately sized window will appear. If you don’t display the component as an icon, you will need to resize the component inside MathConnex in order to get a reasonably sized window in which to work.

- When you click on the “Next” button, the Wizard brings you to the next page where you will specify the number of inputs and outputs.

- When you click “Finish,” you’ll see the Mathcad component in your Worksheet with the appropriate number of input and output ports. For example, a Mathcad component with one input and two output ports would look like this:



If you chose to create a new worksheet, you should enter equations and calculations into it by doing the following:

- Double-click the Mathcad component in the Worksheet to activate it. The Mathcad component opens. The menus and toolbars change to Mathcad menus and toolbars.

Note If the Mathcad component were instead displayed as an icon, a separate Mathcad window would open when you double-click.

- Type in the Mathcad component worksheet just as you would in a regular Mathcad worksheet: enter equations, define functions, create graphs, etc. Use the variable names **`in0`**, **`in1`**, etc. to refer to the inputs. Each input can be a scalar, vector, or matrix.

- Define variables **`out0`**, **`out1`**, etc. if there will be output from the component. The values of these variables will be sent out of the Mathcad component to the next component in the system.

Tip To enlarge the Mathcad component, double-click on it to activate it. You’ll see handles along the sides of the component. Move the cursor to one of these handles so that it changes to a double-headed arrow. Press and hold down the mouse button and drag the cursor in the direction you want the component’s dimensions to change.

When you connect the Mathcad component into a MathConnex system and run the system, the input data flows into the Mathcad component worksheet and is assigned to the Mathcad variables **`in0`**, **`in1`**, etc. The values in **`out0`**, **`out1`**, etc. will flow out of the component.

Editing the Mathcad component

Once you set up a Mathcad component, you may find that you want to add or remove inputs or outputs. To do so:

- Click on the component with the right mouse button to bring up the context menu.
- Choose **Add Input Port**, **Remove Input Port**, **Add Output Port**, or **Remove Output Port**.

To make changes to the equations, graphs, etc. in the Mathcad component, double-click on it to activate it and make the necessary changes.

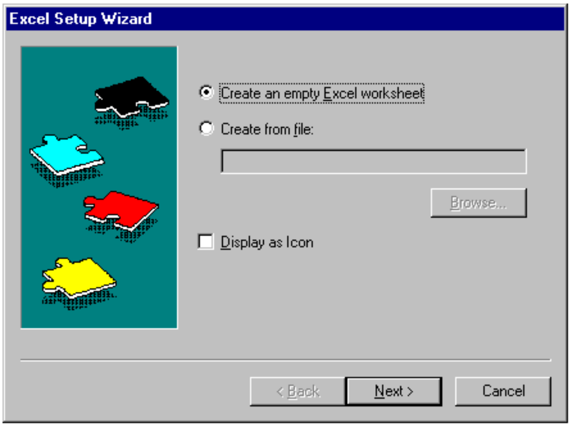
Excel

The Excel component lets you:

- Use an Excel worksheet as a data source for introducing data into a system.
- Manipulate data using Excel functions and operators.
- Display data in an Excel worksheet.

To place the Excel component on your Worksheet:

- Make sure Excel for Windows 95 version 7.0 or higher is installed (but not necessarily running) on your system.
- Drag the X icon from the Component Palettes to your Worksheet. This launches the first part of the Excel Setup Wizard, shown below.
- If you want to connect to an existing Excel file, choose “Create from file,” and type the path name in the text box or use the Browse button to locate the file; then click “Open.” If you don’t want to connect to a previously created file, choose “Create an empty Excel Worksheet.”
- Click the Display as Icon box if you want to display the component as an icon rather than as a viewpoint onto an Excel file.



Excel Setup Wizard

● Create an empty Excel worksheet

○ Create from file:

□ Display as Icon

Tip Although you won’t see the Excel worksheet in the component when you display it as an icon, you can double-click on it to edit it, and a separate, moderately sized window will appear. If you don’t display the component as an icon, you will need to resize the component inside MathConnex in order to get a reasonably sized window in which to work.

- Click on the “Next” button to specify:

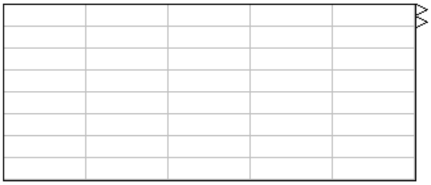
  The number of inputs and outputs: choose a number between 0 and 4 for each.

  Input ranges: the Excel cells in which the values of each input will be stored. Enter the starting cell, which is the cell that will hold the element in the upper left corner of an array of values. For example, for an input variable containing a 3×3 matrix of values, you can specify A1 as the starting cell, and the values will be placed in the cells A1 through C3.

  Output ranges: the Excel cells whose values will be sent as output. For example, enter C2:L11 to output the values in cells C2 through L11.

- Click “Finish.”

You’ll see the Excel component in your Worksheet with the appropriate number of input and output ports. For example, an Excel component that has no inputs but provides two sets of output would look like this:



If you created an empty Excel worksheet or if you want to manipulate the data using Excel, double-click on the Excel component. The Excel component opens and the MathConnex menus and toolbars change to those of Excel.

Figure 4-6 shows an example of an Excel component introducing data to a system.

Note If the Excel component was displayed as an icon, a separate Excel window will open when you double-click on the component.

When you connect the Excel component into a system and run the system, the input data flows into the Excel component in the cells you specified in the Wizard. The output values will be gathered from the cells you specified and flow out of the component.

Tip To see more or fewer rows and columns, double-click on the Excel component to activate it. You'll see handles along the sides of the component. Move the cursor to one of these handles so that it changes to a double-headed arrow. Press and hold down the mouse button and drag the cursor in the direction you want the component's dimensions to change.

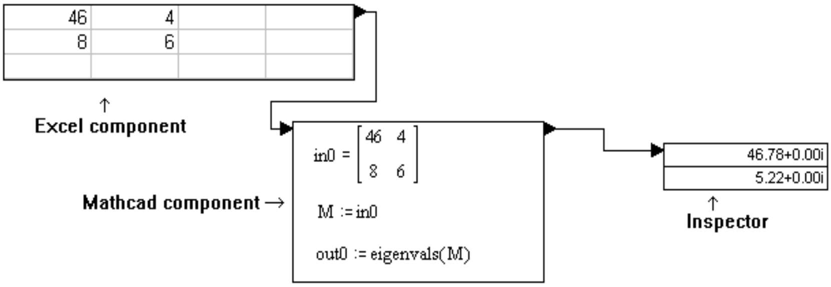


Figure 4-6: Passing data from the Excel component to the Mathcad component for calculations.

Making changes to the inputs and outputs

Once you set up an Excel component, you may find that you want to add or remove input or output variables, or you may want to change the cell ranges for inputs and outputs which you initially specified in the Setup Wizard. To do so:

- Click on the component with the right mouse button to bring up the context menu.
- Choose **Add Input Port**, **Remove Input Port**, **Add Output Port**, or **Remove Output Port**.

When you add input or output ports or wish to reconfigure existing ports, you'll need to specify which cells in the component will store the input(s) and which will provide the output(s). To do so:

- Click on the component with the right mouse button to bring up the context menu.
- Choose **Properties** from the context menu.
- Click on either the Inputs tab or the Outputs tab and specify a range of cells for each input and each output.

MATLAB

The MATLAB component lets you connect to a MATLAB Professional 4.2 program file and pass numerical data between a MathConnex system and a MATLAB file.

When using the MATLAB component, you can:

- Manipulate data using MATLAB functions.
- Use a MATLAB file as a data source for a system.
- Display data in a MATLAB file.

To place the MATLAB component on your Worksheet:

- Make sure MATLAB Professional is installed (but not necessarily running) on your system.
- Drag the .m icon from the Component Palettes to your Worksheet. The MATLAB component will appear in your Worksheet.

By default, the MATLAB component has one input port and one output port. See "Adding and removing ports" on page 29 to find out how to add or remove ports.

- Double-click the MATLAB component in the Worksheet. The MATLAB component opens as a text editing window.
- Type in the MATLAB component worksheet just as you would in a regular MATLAB file. Use the variable names **`in0`**, **`in1`**, etc. to refer to the inputs. Each input can be a scalar, vector, or matrix.

  If there will be output from the component, define variables **`out0`**, **`out1`**, etc. The values of these variables will be sent out of the MATLAB component to the next component in the system.
- Choose **Apply Changes** from the **File** menu or click on the ☑ button.
- Choose **Close and Return** from the **File** menu or press [**`Esc`**].

When you connect the MATLAB component into a system and run the system, the input data will flow into the MATLAB component worksheet as **`in0`**, **`in1`**, etc. The values in **`out0`**, **`out1`**, etc. will flow out of the component.

Note To use names other than **in0**, **in1**, etc. and **out0**, **out1**, etc. click on the component with the right mouse button and choose **Properties** from its context menu. Go to the Input Variables tab to change the input names. Go to the Output Variables tab to change the Output names.

Editing the MATLAB component

Once you set up a MATLAB component, you may find that you want to add or remove inputs or outputs. To do so:

- Click on the component with the right mouse button to bring up the context menu.
- Choose **Add Input Port**, **Remove Input Port**, **Add Output Port**, or **Remove Output Port**.

To make changes to the equations, graphs, etc. in the MATLAB component, double-click on it to activate it and make the necessary changes.

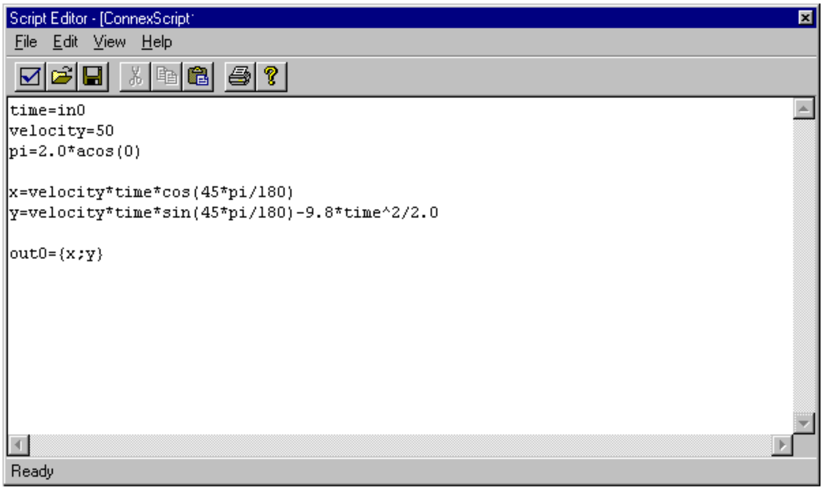
ConnexScript

Although you will usually use the Mathcad component for any data calculations you wish to perform, you can also use the ConnexScript component for short, straightforward calculations using the ConnexScript language and its built-in functions.

To place the ConnexScript component on your Worksheet:

- Drag the icon from the Component Palettes onto the Worksheet. The ConnexScript component appears as an icon with one input port and one output port by default. See “Adding and removing ports” on page 29 to find out how to add or remove ports.

- Double-click on the component to bring up the Script Editor:



```
time=in0
velocity=50
pi=2.0*acos(0)

x=velocity*time*cos(45*pi/180)
y=velocity*time*sin(45*pi/180)-9.8*time^2/2.0

out0={x;y}
```

- Enter ConnexScript statements to manipulate the input data and define output. By default, the inputs have the variable names **`in0`**, **`in1`**, etc. Use these names to refer to the inputs in Script Editor. Outputs should be defined with the variable names **`out0`**, **`out1`**, etc.
- Choose **Apply Changes** from the **File** menu or click on the ☑ button.
- Choose **Close and Return** from the **File** menu or press [**`Esc`**].

For detailed information on ConnexScript syntax and built-in functions, see the section “ConnexScript language reference” in Chapter 5.

Tip Clicking the ☑ button runs the script so that you can see any errors while the Script Editor window is open.

Changing the names of the inputs and outputs

Although the inputs and outputs are known as **`in0`**, **`in1`**, etc. and **`out0`**, **`out1`**, etc. you can change these names by doing the following:

- Click on the component with the right mouse button.
- Choose **Properties** from the context menu.
- On the Inputs tab, use the text boxes to supply different names for the inputs.
- On the Outputs tab, use the text boxes to supply different names for the outputs.

Editing the ConnexScript component

Once you set up a ConnexScript component, you may find that you want to add or remove inputs or outputs. To do so:

- Click on the component with the right mouse button to bring up the context menu.
- Choose **Add Input Port**, **Remove Input Port**, **Add Output Port**, or **Remove Output Port**.

To make changes to the equations, graphs, etc. in the ConnexScript component, double-click on it to activate it and make the necessary changes.

Importing text to the ConnexScript component

You can import text from other files to the ConnexScript Editor. The source file types recognized are ConnexScript (.MXS) and ASCII text (.TXT).

To import the contents of another file:

- Double-click on the ConnexScript component to open the ConnexScript Editor.
- Position the cursor at the line where you want to import code.
- Choose **Import** from the **File** menu. The Import dialog box appears.
- Navigate to the file you want to import.
- Click “Open.”

The contents of the file is added to the ConnexScript text at the position the cursor was in when the import command was invoked.

Exporting text from the ConnexScript component

You can export text from the ConnexScript Editor to other files. The source file types recognized are ConnexScript (.MXS) and ASCII text (*.TXT).

To export the contents of the ConnexScript Editor to another file:

- Double-click on the ConnexScript component to open the ConnexScript Editor.
- Position the cursor at the line where you want to export code.
- Choose **Export** from the **File** menu. The Export dialog box appears.
- Specify the path and filename of the target file.

- Select the desired file type.
- Click “Save.”

The entire contents of the ConnexScript Editor window is exported to the target file.

Components for controlling data flow

When you connect two MathConnex components and run the system, the data flows from the output port of one component along the connecting wire to the input port of the next component. In some cases, however, you may want to halt the flow of data along the wire or control exactly which data values are passed through.

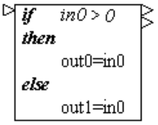
- You can use the Stop/Pause component to stop a running system.
- Using the Wire Breaker component you can quickly prevent or allow data to flow through a wire.
- The Conditional component lets you send certain data values depending on whether a conditional statement is true or false.
- The Initialize component lets you send data from the first input port of a component during the first run and from the second input port for subsequent runs.

Conditional

Using the Conditional component you can send either one set of data as output or another set depending on whether a conditional statement is true or false.

To insert the Conditional component into your Worksheet:

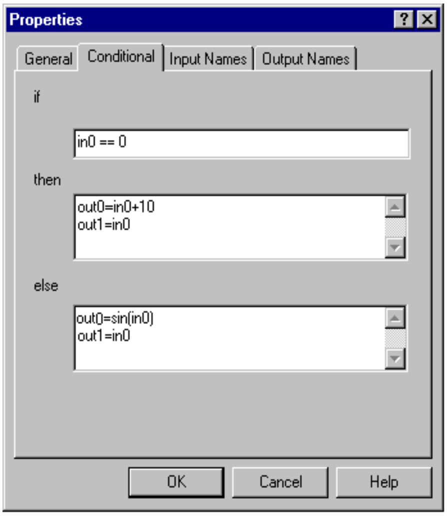
- Drag the icon to the Worksheet. The Conditional component appears in your Worksheet.



```
if    in0 > 0
then
        out0=in0
else
        out1=in0
```

Note The component defaults to having two input ports and two output ports, but you can add or remove any by using the appropriate commands on the component’s context menu.

- Click on the component with the right mouse button and choose **Properties** from the component’s context menu.
- Click on the Conditional tab, shown below.



if

```
in0 == 0
```

then

```
out0=in0+10
out1=in0
```

else

```
out0=sin(in0)
out1=in0
```

- In the “If” section, enter a single-line conditional expression using a ConnexScript statement as described in the section “ConnexScript language reference” in Chapter 5.

Tip Some valid conditional statements include:

`in0 < in1` (*in0* is less than *in1*)

`in0 < in1 & in0!= 0` (*in0* is less than *in1* AND *in0* is not equal to 0)

`in0 = 10` (*in0* is defined as 10)

`in0 = = 0` (*in1* is equal to 0)

- In the “Then” section, enter any number of ConnexScript statements to determine what the component will output if the conditional statement is true. Use **`in0`**, **`in1`**, etc. and **`out0`**, **`out1`**, etc. to refer to the inputs and outputs, respectively.
- In the “Else” section, enter any number of ConnexScript statements determining what the component will output if the conditional statement is false. Use **`in0`**, **`in1`**, etc. and **`out0`**, **`out1`**, etc. to refer to the inputs and outputs respectively.

An example of a system using the Conditional component is shown in Figure 4-7.

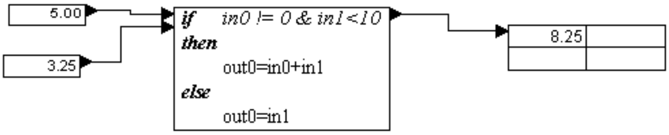


Figure 4-7: The Conditional component sends output based on whether the If” statement is true.

Note You can use the Input Variables and the Output Variables tabs in the Properties dialog to specify different names for the inputs and outputs. For example, in Figure 4-8, the second output in the Conditional component is named “stop” rather than “out1.”

When a system containing the Conditional component runs, the Conditional component is triggered when it receives valid inputs. When it’s triggered, it determines the output, and sends it through the output port. If one of the outputs does not get defined when the component is triggered, no output is sent through its corresponding output port.

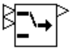
Tip If you don’t want any data to be sent when a statement is true or false, you can leave the “Then” or “Else” sections blank. If there are no statements in the “Else” section, you will not see that section when looking at the Conditional component in a system.

Initialize

Each time you run a system, a component will usually take input from all of its input ports. The Initialize component, however, takes input from one input port the first time you run the system and from another input port during subsequent runs. This is useful for iteration where an initial condition is set and then future values are passed back through the system.

To insert the initialize component onto a Worksheet:

- Drag the ↳ icon from the Component Palettes onto the Worksheet. The Initialize component appears in the Worksheet.

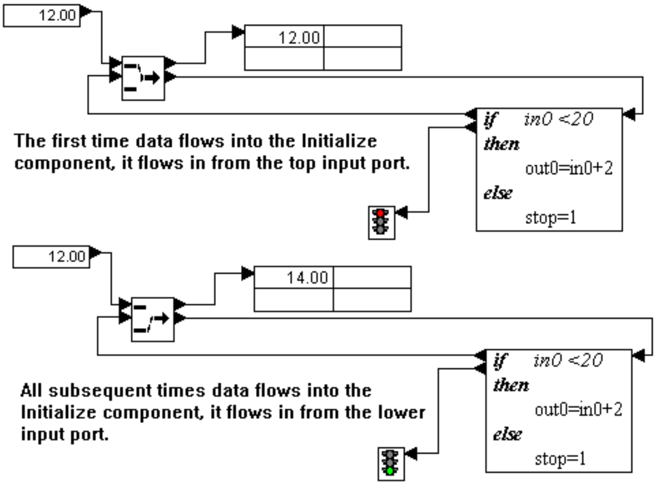


  The Initialize component has two input ports. The component takes input from its top input port the first time data flows into the component. Each subsequent time, input is taken from the lower input port. The component’s appearance changes to indicate when it is getting data from the top or bottom input port.

- Connect the output ports of some component(s) to the top and bottom input ports of the initialize component.

When you run the system for the first time, data flows into the Initialize component through the upper input port and back out. When the data flows into the component any other times, it flows in through the lower input port and back out.

Note The Initialize component doesn’t change the input in any way. It simply directs the input back into the system.



The first time data flows into the Initialize component, it flows in from the top input port.

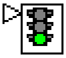
All subsequent times data flows into the Initialize component, it flows in from the lower input port.

Figure 4-8: The Initialize component lets you specify an initial value for a system.

Stop/Pause

To stop or pause a running system, you can always press the ■ button or the ⏸ button in the MathConnex toolbar or choose **Stop** or **Pause** from the **Run** menu. However, to avoid pressing these buttons every time you want to stop or pause a system, you can insert the Stop/Pause component into a system. This component stops or pauses a running a system when it receives data on its input wire.

To insert the Stop/Pause component:



- Drag the 🚦 icon from the Component Palettes onto the Worksheet. The Stop/Pause component appears.
- Connect the output port from a component to the input port of the Stop/Pause component.

By default, when you run a system containing the Stop/Pause component, the system stops when a value is passed into it. To make the Stop/Pause component pause instead:

- Click on the component with the right mouse button.
- Choose **Pause on Input** from the context menu.

To make the Stop/Pause component beep when a data value goes into it:

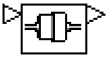
- Click on the component with the right mouse button.
- Choose **Beep When Active** from context menu.

If you connect the Conditional component to the Stop/Pause component, you can force the system to stop or pause under certain conditions. In Figure 4-8, for example, the Stop/Pause component becomes active when a value exceeds 20.

Wire Breaker

As shown in Figure 4-9, using the Wire Breaker component you can easily alternate between allowing data to flow through a wire and preventing data from flowing through a wire.

To insert the Wire Breaker component:



- Drag the icon from the Component Palettes onto the Worksheet. The Wire Breaker component appears with one input port and one output port.
- Connect the output port from a component to the input port of the Wire Breaker component.
- Connect the output port from the Wire Breaker to the Input port of the next component in the system.

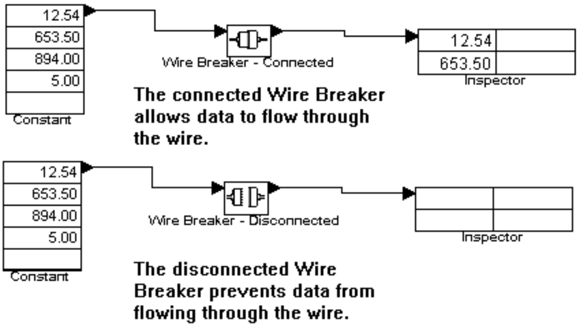
By default, the Wire Breaker component allows data to flow through it when you run the system. To prevent data from flowing:

- Click on the component with the right mouse button.
- Choose **Disconnect the Wire** from the context menu.

Tip The Wire Breaker component is useful when part of a system takes a long time to calculate and you want to avoid passing data into it but want to keep the entire system connected.

To allow data to flow again:

- Click on the component with the right mouse button.
- Choose **Connect the Wire** from the context menu.



The connected Wire Breaker allows data to flow through the wire.

The disconnected Wire Breaker prevents data from flowing through the wire.

Figure 4-9: The Wire Breaker component allows you to selectively run parts of the system.

Note The Wire Breaker component, when connected, doesn't change the input in any way.

Other components

Many of the basic components are designed for manipulating data in a specified way. The Text component and the Scripted Object component are slightly different. The Text component does not manipulate data; it is simply an OLE object you can insert into a Worksheet to annotate it. The behavior of the Scriptable Object component depends on how you script it.

Text

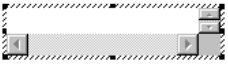
The Text component allows you to

- Enter text anywhere above, below, or beside the components in the Worksheet.
- Set the font, style, and size of the text.

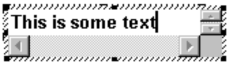
Entering text

To place text on a Worksheet:

- Drag the A icon to the Worksheet. You'll see the Text component window.



- Begin typing text directly into the window.



This is some text

You can type beyond the length of the text box, but MathConnex displays only as much text as allowed by the width of the text box. If you want to display more text:

- Double-click on the Text component to activate it.
- Move the cursor to the right or bottom handle until it changes to a double-headed arrow.
- Hold the mouse button down and drag outwards.

Changing the font and setting tabs

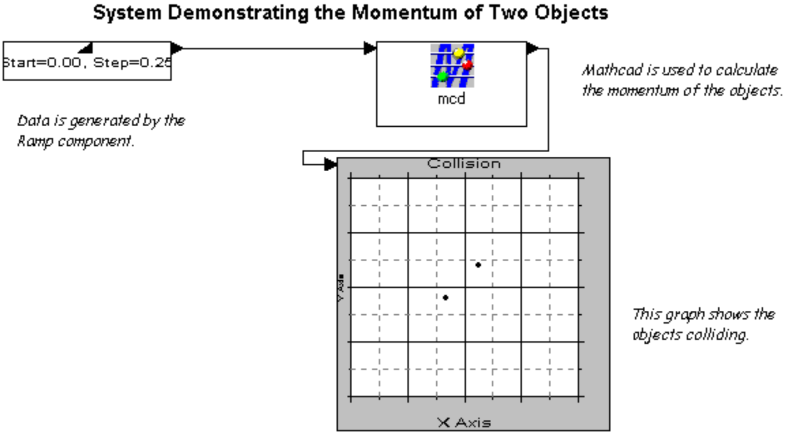
To change the font of the text in a Text component:

- Double-click on the Text component to activate it.
- Choose **Set Fonts** from the **View** Menu.
- Select the font, style, and size of your text.
- Click "OK."

Note The font settings are saved for each text component separately. You can have several Text components in your Worksheet and set the fonts differently for each.

To set the tab stops to a certain number of spaces:

- Double-click on the Text component to activate it.
- Choose **Set Tab Stops** from the **View** Menu.
- Enter the number of spaces the [**Tab**] key should insert in the Text component.
- Click “OK.”



System Demonstrating the Momentum of Two Objects

Mathcad is used to calculate the momentum of the objects.

Data is generated by the Ramp component.

This graph shows the objects colliding.

Figure 4-10: A MathConnex system annotated with text.

Editing the text in a text component

To cut, copy, paste, and delete text:

- Double-click on the Text component to activate it.
- Drag-select text in the Text component.
- Choose the appropriate option from the **Edit** menu.

The **Edit** menu also gives you access to the **Find** and **Replace** commands for finding and replacing words in a Text component and automatically wrapping the text.

Scripted Object

You use the Scripted Object component to write a custom *script* (or program) for an OLE object so that it accepts input and sends output just like other built-in components. Choose **Scripted Object** from the **Insert** menu to insert a Scripted Object component. See Chapter 5, “Advanced Topics,” for more information.

Chapter 5
Advanced Topics

This chapter introduces topics to help you get more out of MathConnex and to extend its functionality.

MathConnex run model

How components are triggered in MathConnex systems; parallel processing; feedback.

Scripted Object component

How to insert and configure a custom Scripted Object component to extend the functionality of MathConnex.

ConnexScript language reference

Syntax, functions, and operators for use in the ConnexScript and Conditional components.

MathConnex run model

Chapter 3 introduced running, pausing, stopping, and single-stepping through a MathConnex system. This section provides additional information about how MathConnex triggers the components of systems.

Filters, sinks, and sources

MathConnex is a visual tool that provides a data flow programming environment. MathConnex components in this environment fall into three functional categories:

- *Sources*, which introduce data into systems. Sources include the Input, File Read, and Ramp components.
- *Filters*, which take one or more data inputs and pass along one or more data outputs, usually with computational steps in between. Examples of filters are the Mathcad, Excel, ConnexScript, and MATLAB computational components.
- *Sinks*, which receive data inputs and do not pass them further in a system, although they may process the data. The Stop/Pause component is the only true sink, although any component that is configured to have only input ports behaves as a sink.

Filters and Sinks are triggered to run whenever they have received *all* of their input values on their input port(s). Sources, on the other hand, have one of two options:

- They may generate output once per system execution.
- They may generate output "continuously," i.e., as long as the system is running and all outputs are clear. An output is considered "clear" when the component on the other end of a wire has retrieved the last value from the wire.

Each source component has a **Continuous Output** command on its context menu that controls which output behavior it will have. Select **Continuous Output** so that it is checked to make a component generate output continuously.

Note When they are configured to have *only* output ports, the Mathcad, Excel, ConnexScript, and MATLAB components behave as source components, and show the **Continuous Output** option on their context menus.

When you run a system containing the Stop/Pause component, the system stops or pauses automatically when a value is passed into this component. If you run a system that does not contain this component, the system will run continuously until you pause or stop it using the ⏸ or ⏹ Toolbar button or the corresponding command on the **Run** menu.

Parallel processing and execution steps

In MathConnex, parallel paths of execution can be accomplished in two ways:

- By placing two or more unconnected systems on the Worksheet.

- By branching along multiple paths by using multiple output wires from a single component. These wires may take different paths through the system.

When you run your system(s), all components—even those in unconnected systems—that are able to begin running at a particular time constitute a *time step* in execution. The slowest component that is able to run within a time step determines when the next time step begins. The overall speed of the system is the sum of the time steps.

You can always see the exact order of execution in your system(s) by selecting **Highlight Components** from the **Run** menu and then repeatedly choosing **Step** from the **Run** menu.

The **Single Step Mode** command on the **Run** menu allows you to control how you step through the parallel parts of the system. If you select **Single Step Mode** from the **Run** menu so that the command is checked, MathConnex alternates through the steps in each system one at a time as each component is ready; otherwise, MathConnex moves through all systems concurrently as the next set of components becomes ready.

Feedback

Although not explicitly designed as a simulation environment, MathConnex can be applied to feedback problems that arise in engineering, physical, and life sciences. The critical component for simulating feedback is the Initialize component, which you insert into the Worksheet with the ↳ button on the Component Palettes. Several of the sample MathConnex projects in the **`samples`** folder use the Initialize component.

The Initialize component takes input from the upper input port the first time you run the system and from the lower input port during subsequent runs. Typically you pass *initial conditions* for a system through the first input port of the Initialize component, and you then feed values computed further down in the system back into the second input port to begin a new cycle (*feedback loop*) of computation. Unless you are designing a system to run continuously, you will need to define some termination condition in your system, usually with a Conditional component, to stop the feedback loop.

Note If you plan to feed several values back through a system, you usually need to pass a *vector* of values through the Initialize component.

Scripted Object component

MathConnex has specific components for managing interapplication data flow with Mathcad, Axum, Excel, and MATLAB. However, you can exchange data between MathConnex components and any object that supports OLE2 Automation, even if MathConnex does not have a specific component to do so. You use the Scripted Object component to write a custom *script* (or program) for an object so that it:

- Accepts values from MathConnex components that are wired to its input port(s).
- Activates the server application or control to manipulate the data when the MathConnex system is running.
- Sends values to MathConnex components wired to its output port(s).

For example, you may want to design a MathConnex system in which components send data to a Lotus 1-2-3 worksheet, where the data are transformed and output to other MathConnex components in the system.

To create a Scripted Object component, you must:

- Be proficient in a supported scripting language, such as Microsoft VBScript or JScript, that is installed on your system.
- Understand the way the OLE server, OLE control, or ActiveX control that you are trying to script has implemented OLE Automation.
- Have the server or control available on your system.

More on scripting languages

Before you insert a Scripted Object component into the MathConnex Worksheet, you need to have a supported scripting language installed on your system. As this Getting Started Guide goes to press, the following two scripting languages are supported: Microsoft VBScript (Visual Basic Scripting Edition) version 2 and Microsoft JScript (an implementation of JavaScript) version 2. Both of these scripting languages can currently be downloaded at no charge from Microsoft, Inc.'s Web sites:

http://www.microsoft.com/vbscript
http://www.microsoft.com/jscript

VBScript is a strict *subset* of the Visual Basic for Applications language used in Microsoft Excel, Project, Access, and the Visual Basic 4.0 development system. VBScript is designed to be a lightweight interpreted language, so it does not use strict types (only Variants). Also, because VBScript is intended to be a safe subset of the language, it does not include file input/output or direct access to the underlying operating system.

JScript is a fast, portable, lightweight interpreter for use in applications that use ActiveX Controls, OLE automation servers, and Java applets. JScript is directly comparable to VBScript (not Java). Like VBScript, JScript is a pure interpreter that processes source code rather than producing stand-alone applets.

The syntax and techniques used in the scripting language you choose are beyond the scope of this *Getting Started Guide*. For more information about Microsoft VBScript and JScript, consult Microsoft, Inc.'s Web sites.

Inserting a Scripted Object component

To insert a Scripted Object component into the MathConnex Worksheet:

- Choose **Scripted Object** from the **Insert** menu.

This launches the Scripting Wizard. First specify the OLE server, OLE control, or ActiveX control from which you want to create a Scripted Object. The Object to Script scrolling list shows available objects on your system. Choose an object that supports the OLE2 Automation interface.

Note The fact that an object appears on the Object to Script scrolling list does not necessarily indicate that it supports the OLE2 automation interface to work as a Scripted Object in MathConnex. You'll need to consult the documentation for any OLE server, OLE control, or ActiveX control you script in MathConnex.

You must specify:

- Whether the object will be a new file or whether you will insert a file that already exists.
- Whether you will see a viewport on the file in the MathConnex Worksheet or whether you'll see an icon.

When you click the "Next" button, the Wizard brings you through other dialog boxes where you specify:

- Which scripting language you will use.
- The name by which you will refer to the object in your script.
- The number of input and output ports the object will have.

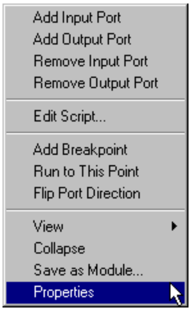
Properties of the component

Like other OLE objects you insert into the Worksheet, a Scripted Object component has the following properties:

- You select the object in the Worksheet by clicking once on it. Move, cut, copy, and delete the selected object like any other MathConnex component.
- Double-click the object to activate it or to resize it. Unless you inserted an icon, you'll see the object activate in-place for editing, and the menus and toolbars will change to those of the other application. Click outside the object to resume working in MathConnex.

Unlike other OLE objects you insert into the Worksheet, however, a Scripted Object component displays input and output ports and can pass data in a MathConnex system:

- Click once with the right mouse button to see a context menu for the component. You access a properties page, configure the run options, and add and remove input and output ports by choosing commands from the context menu.
- Connect the component to other MathConnex components in the usual way, by drawing a wire



from another component's output port to an input port or from an output port to another component's input port.

Object model

The Scripted Object component has the following predefined objects, properties, and methods that enable you to configure it to work as a MathConnex component.

Collections

- **`Inputs`** and **`Outputs`** are predefined *collections* of DataValue objects (see below) containing the Scripted Object's inputs and the outputs, respectively.
- The **`Count`** property can be used to query the total number of elements in the collection. For example, **`Outputs.Count`** returns the number of output ports.
- The **`Item`** method is used to specify an individual element in the collection. To refer to a particular input or output, use the notation **`Inputs.Item(`***n***`)`** or **`Outputs.Item(`***n***`)`**, where *n* is the index of the input or output. The index *n* always starts from 0. Since **`Item`** is the default method, languages such as VBScript and JScript let you drop the method name to imply the default method. For example, **`Inputs(0)`** is equivalent to **`Inputs.Item(0)`** and references the first input.

DataValue objects

- The **`Value`** property accesses a DataValue's real part. For example, in VBScript or JScript **`Inputs(0).Value`** returns the real part of the first input.
- The **`IValue`** property accesses a DataValue's imaginary part. For example, in VBScript or JScript **`Outputs(1).IValue`** returns the imaginary part of the second output. If there is no imaginary part, the **`IValue`** portion returns "NIL."
- The **`IsComplex`** property returns "TRUE" if a DataValue has a valid imaginary part; this property returns "FALSE" otherwise. For example, the expression **`(inputs(0).IsComplex)`** returns "FALSE" if the first input has only a real part.
- The **`Rows`** and **`Cols`** properties yield the number of rows and columns.

Global methods

- The **`alert`** function takes a single string parameter that is presented to the user as a standard modal Windows message box with an "OK" button.
- The **`errmsg`** function takes a single string parameter that displays as an error message from within the script and causes the script to stop execution. The second parameter is also a string, but it is optional. It is used to display the source of the error.

Note In JScript, the names of functions, methods, objects, and properties are case sensitive, while in VBScript they are not.

Scripting the object

To start scripting an inserted Scripted Object component:

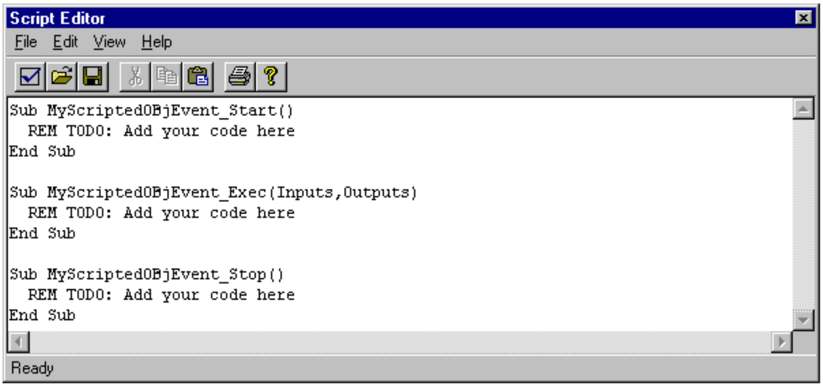
- Click once on the component with the right mouse button to see the context menu.
- Choose **Edit Script** from the context menu.

You'll see a new window called the Script Editor containing three subroutine stubs in which you insert your own scripting code. Figure 5-1 shows an example of the VBScript shell you'd see for a new scripted object called **`MyScriptedObj`**.

The script you write will usually contain at a minimum the following three subroutines:

- A *starting* routine, called once when execution of the system begins. This is a good place to initialize variables, open files for reading and writing, etc.
- An *execution* routine, called every time the component receives or outputs data values. By default it takes as arguments the collections **`Inputs`** and **`Outputs`**.
- A *stopping* routine, called once when execution of the system stops.

What you will include in these subroutines is determined largely by the properties of the OLE object you are scripting; consult the documentation for the server or control.



```
Sub MyScriptedOBjEvent_Start()
  REM TODO: Add your code here
End Sub

Sub MyScriptedOBjEvent_Exec(Inputs,Outputs)
  REM TODO: Add your code here
End Sub

Sub MyScriptedOBjEvent_Stop()
  REM TODO: Add your code here
End Sub
```

Figure 5-1: The Script Editor window shows the VBScript shell for an object named **`MyScriptedObj`**. *You write the code to configure the object.*

To resume working in MathConnex when you have finished writing your script, choose **Close and Return** from the Script Editor's **File** menu, or press [**`Esc`**].

For examples of Scripted Object components with working scripts, see the **`samples`** folder in the location where you installed Mathcad and MathConnex. Bear in mind that to run these sample projects with Scripted Object components, you will need to install any applications or controls that were used to create those components.

ConnexScript language reference

ConnexScript is a lightweight mathematical programming language you use in the ConnexScript and Conditional components of MathConnex. It provides basic scientific calculator functionality and is particularly useful for computational flow control in cases where you don't need the full functionality of the Mathcad, Excel, or MATLAB component.

ConnexScript has a familiar mathematical syntax similar to that in popular matrix language products. In addition, many mathematical operators, such as matrix multiplication and division, are built into the language, as are basic and user-defined mathematical functions.

Data types

ConnexScript supports real and complex data.

Real numbers

ConnexScript uses double-precision, IEEE format floating point numbers. E-format notation is supported.

Examples

```
314          3.14         5.78e14
```

Complex numbers

Complex numbers consist of:

- a real part, which is a real number.
- an imaginary part, which is stored as a real number but is equivalent to a real number multiplied by the square root of –1.

To facilitate entering complex numbers, ConnexScript supports both the *i* and *j* notation appended to the end of numerical constants to indicate an imaginary number.

Examples

```
5.78i               0.5e10i             4.0 + 8.7j
```

Infinite and Not-a-Number

ConnexScript has built-in support for Infinite (**`Inf`**) and Not-a-Number (**`NaN`**) values, which can often result from errors in calculations. Infinite and Not-a-Number values can also be assigned to variables directly, using the pre-defined variables **`Inf`** and **`NaN`**, as well as their capitalized and uncapitalized permutations (**`inf`**, **`Nan`**, etc.).

Examples

```
x = Inf             y = NaN
```

Operators

Operator	Description
`=`	assignment
`+`	addition
`-`	subtraction
`*`	multiplication
`/`	division
`^`	power
`.*`	elementwise matrix multiplication
`./`	elementwise matrix division
`.^`	elementwise matrix power
`~`	logical (Boolean) NOT
`xor`	logical (Boolean) XOR
`!=`	not equal to
`>=`	greater than or equal to
`<=`	less than or equal to
`&`	logical (Boolean) AND
`|`	logical (Boolean) OR
`==`	equal to
`>`	greater than
`<`	less than

Note Addition, subtraction, multiplication, division, and power can take either scalar or array arguments.

Functions

In general, ConnexScript built-in functions take either real or complex arguments. User-defined functions are discussed on page 90. Function names are case sensitive.

Basic math functions

Function	Description
`abs`	returns absolute value
`ceil`	rounds up to next integer
`exp`	exponential
`floor`	rounds down to previous integer
`log10`	computes base 10 logarithm
`log2`	computes base 2 logarithm
`ln`	natural logarithm
`max`	returns maximum value of variable
`min`	returns minimum value of variable
`mod`	returns the remainder after the first argument is divided by the second.
`nelem`	returns the number of elements in a variable
`round`	rounds a value to the closest integer
`sign`	returns the sign of the input variable
`sqrt`	returns square root of input variable
`time`	returns number of seconds since January 1, 1980
`trunc`	drops the decimal portion of a value

Complex math functions

Function	Description
`conj`	returns complex conjugate
`im`	returns imaginary part of a number
`re`	returns real part of input variable

Trigonometric functions

Function	Description
cos	cosine
sin	sine
tan	tangent
sec	secant
csc	cosecant
cot	cotangent
pi	returns the value of pi
acsc	arc/inverse cosecant
acos	arc/inverse cosine
acot	arc/inverse cotangent
asec	arc/inverse secant
asin	arc/inverse sine
atan	arc/inverse tangent

Hyperbolic trigonometric functions

Function	Description
cosh	hyperbolic cosine
coth	hyperbolic tangent
csch	hyperbolic cosecant
sech	hyperbolic secant
sinh	hyperbolic sine
tanh	hyperbolic tangent
acsch	arc/inverse hyperbolic cosecant
acosh	arc/inverse hyperbolic cosine
acoth	arc/inverse hyperbolic cotangent
asech	arc/inverse hyperbolic secant
asinh	arc/inverse hyperbolic sine
atanh	arc/inverse hyperbolic tangent

Matrix and special functions

Function	Description
cols	returns number of columns in a matrix
rows	returns number of rows in a matrix
det	returns determinant of a matrix
gamma	returns gamma function

Reserved words

The following words cannot be used as variable or function names:

break
cols
complex
delete
else
elseif
end
error
for
function
if
in
list
load
nelem
new
real
repeat
return
rows
static
until
while
xor

Variables

Variables in ConnexScript:

- must begin with an alphabetical character
- may contain a combination of letters and numbers, including an underscore character (_)
- may not be the same as one of the ConnexScript reserved words

- may not contain special characters that are used as ConnexScript operators
- may not contain an embedded space
- are case sensitive

Examples

```
this_is_my_variable     t1

x_5                     R2D2
```

Note In a ConnexScript or Conditional component, by default you use the variable names **`in0`**, **`in1`**, etc. for inputs and the variable names **`out0`**, **`out1`**, etc. for outputs.

Creating vectors and matrices

ConnexScript supports creation of vectors and matrices in two ways:

- static array notation
- colon vector notation

Static array notation

In a static array declaration:

- curly braces (**`{`** and **`}`**) are used to denote the beginning and end of the static declaration
- the comma (**`,`**) is used to separate values along the same row
- the semicolon (**`;`**) is used to separate the next row

```
{ expr, expr ; expr, expr }
```

For example, to create a row vector using static array notation, you would type:

```
x = { 1, 2, 3 }
```

To create a 2 by 3 matrix using static array notation you would type:

```
x = { 1, 2, 3; 4, 5, 6 }
```

Note The semicolon begins the second row. When multiple rows are declared, the lengths of the vectors representing each row must be equal.

Example 1

```
{ 1, x, (y*z) ; z, 2.89, 4 }  // semicolon indicates new row
```

Example 2

```
x = { 1, 2, 3, 4 }          // 1-by-4 vector

A = { 1, 2, 3; 4, 5, 6 }          // 2-by-3 matrix
```

Colon vector notation

In a colon vector declaration, start, end, and optional step values are used to automatically generate a range of values for a vector, where the colon (`:`) is used to separate the expressions.

```
start_expr : step_expr : end_expr
```

For example, to create a vector spanning the values for 1 to 100, in increments of 2, you would type

```
x = 1:2:100
```

When the step value is omitted, ConnexScript defaults to a step value of 1, or, when the start value is greater than the end value, a step value of –1.

Examples

```
y = 1:10        // default step 1
y = 10:1        // automatically step -1
a = 1:5:1000        //1 to 1000 step 5
```

Expressions

A ConnexScript expression is some combination of variables, constants, operators, and functions that indicates the computation of a value.

Constant expressions

Constant expressions contain only constant values:

```
7                  7 + 8 * 19 / 3.3
```

Variable expressions

Variable expressions contain simple variables or simple variables and operators:

```
x                  x + 8              x / y * 8
```

Indexed variable expressions

Indexed variable expressions contain vectors or array variables which are to be indexed:

```
x = y[5]           A[3] = B[5,3] * x
```

Note ConnexScript uses zero-based indexing, so 0 is the first element, 1 is the second element, etc.

Function call expressions

Function call expressions contain function invocations: either built-in functions or user-defined functions, as in this example:

```
y = sin(x)
```

Numerical Expressions

Numerical expressions contain a numerical operator:

expr* + *expr	scalar or matrix addition
expr* - *expr	scalar or matrix subtraction

`expr * expr`	scalar or matrix multiplication
`expr .* expr`	elementwise matrix multiplication
`expr ^ expr`	scalar or matrix power
`expr .^ expr`	elementwise matrix power
`expr / expr`	scalar division or matrix right division
`expr ./ expr`	elementwise matrix division

Boolean conditional expressions

Boolean conditional expressions contain a Boolean logical or relational operator:

`~ expr`	logical NOT
`expr xor expr`	logical exclusive-OR
`expr | expr`	logical OR
`expr & expr`	logical AND
`expr == expr`	equality comparison
`expr != expr`	inequality comparison
`expr < expr`	less than comparison
`expr <= expr`	less than or equal to comparison
`expr > expr`	greater than comparison
`expr >= expr`	greater than or equal to comparison

Comments

ConnexScript supports both in-line and multiple-line comments.

In-line comments

Double forward slashes (`//`) begin code comments that go to the end of the line.

Example

```
x = A[1,2;0]        // take first element from 2nd and 3rd row
```

The text typed following the `//` (displayed here in italics) is ignored.

Multiple-line comments

A forward slash followed by an asterisk (`/*`) begins a multiple-line comment, and an asterisk followed by a forward slash (`*/`) ends a multiple-line comment. The text inside the `/*` and `*/` is ignored.

Statements

Multiple statements

ConnexScript supports multiple statements on a line. The statements must be separated by a semicolon (`;`).

```
statement ; statement
```

Examples

```
x = y + 5; z = x^2

x = 0; for i in 0:5; x = x + i; end
```

Line continuation

An underscore (_) followed by a carriage return indicates continuation of a line of code.

Example

```
A = { 1, 2, 3; _
      4, 5, 6; _
      7, 8, 9 }       // 3-by-3 matrix
```

Function call statements

ConnexScript functions have the following calling sequence:

```
result = funcname ( argument1,  argument2, ... )
```

where ***result*** is the returned value of the function stated in ***funcname***; ***argument1***, ***argument2***, etc., are any required parameters; and the comma is required between arguments (parameters).

Example

```
y = sin( x )          // call a built-in function
```

If statement

The ConnexScript **if** statement is used with the **elseif** and **else** statements for conditional branching.

```
if boolean_expr
      statement1
      statement2
      ...
elseif boolean_expr
      statement3
      ...
else
      statement4
      ...
end
```

In an **if** statement, when the ***boolean_expr*** following the **if** evaluates to "true" (nonzero), the statements within the **if** block are executed. Otherwise, execution skips over the if block to the **elseif** condition (if present) or directly to the **else** block (if present). The **elseif** block and the **else** block are optional.

If the **elseif** block is present, the statement following the **elseif** is executed whenever the **if** ***boolean_expr*** evaluates to "false" (zero) and the **elseif** ***boolean_expr*** evaluates to "true" (nonzero). You may have more than one **elseif** block.

If the **else** block is present, the statement following the else is executed whenever the preceding if and elseif expressions (if present) evaluate to "false" (zero).

Example

```
if( x > y & x != 0 )
      z = y / x
      q = log(2^z)
elseif( y >= x & y != 0 )
      z = x / y
      q = 2^z
else
      z = 0
      q = 1
end
```

For statement

The **for** statement is an iterative, or looping, statement.

```
for identifier in expr
      statement1
      statement2
      ...
end
```

In a **for** statement, a scalar value (***identifier***) is iterated over a range of values given in the expression (***expr***). Each successive iteration updates the loop value to the next value in the expression. For example, **for i in 1:10** iterates the value **i** over the range 1–10, as given by the colon vector expression **1:10**.

Typically, the expression will be a colon vector of the form **1:10**, or the number of elements in columns or rows of a matrix, such as **0:(rows(A)-1)**.

As in a Mathcad for loop, the start and end range need not be sequential. For example, if **x** is a vector containing the elements **{1, 3, 8, 23, 47}**, we can use **x** as a source of indices into a matrix **A** as follows:

```
y = 0
for i in x
      y = y + A[i]
end
```

Tip The **break** statement can be inserted inside of a loop to terminate the loop prematurely.

While statement

The **while** statement is a conditional looping statement that is executed repeatedly while a condition remains true.

```
while expr
      statement1
      statement2
      ...
end
```

In a **`while`** statement, when the condition expression (***`expr`***) following the **`while`** evaluates to “true” (nonzero), the statements inside the while block are executed. After the statements contained within the **`while-end`** are executed, program control returns to the top of the loop. The process repeats until the condition expression evaluates to “false” (zero).

Example

```
i = 0
while( i < 100 )                // using while loop
      A[i] = A[i] * 4
      i = i + 1
end
```

Tip The **`break`** statement can be inserted inside of a loop to terminate the loop prematurely.

User-defined functions

When one of the ConnexScript built-in functions does not satisfy your requirements, you can write a new function using the function declaration. You may define a function anywhere in your ConnexScript script. The function declaration has the form:

```
function funcname ( paramdef1, paramdef2, ... )
      statement1
      statement2
      ...
      return
end
```

where each ***`paramdef`*** is the name of a variable passed into the function. All variables are passed by reference. The **`return`** statement is optional, and can be placed anywhere inside the function in order to “return” from the function prematurely or due to some programmatic condition. Upon reaching the final end statement, the function automatically returns the value of the variable ***`funcname`***, which you need to assign somewhere in the body of your program.

Return value

ConnexScript functions return their value by assignment to a variable of the same name as the function. The return statement does not take any additional arguments. For example, to return a value from the function **`myfunc`**, you would simply assign a value to the variable named **`myfunc`** inside the function body, such as **`myfunc = x + y`**. By default, functions have a return value of 0.0. User-defined functions may call themselves recursively.

Environment

The ConnexScript component can automatically load ConnexScript files with the .MXS extension that are located in the **`MXSLIB`** or **`MXSUSER`** folder. When a function called in a ConnexScript script is not found by its name as a built-in function or as a user-defined function in the script and a .MXS file with the same name as the function exists in the **`MXSLIB`** or **`MXSUSER`** folder, the .MXS file is loaded.

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