



**Ministry of Higher Education And Scientific Research**

**AL-Mustaqbal University College**

**Department of Computer Engineering Techniques**

# **Control Foundations**

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## Experiment no.1: The Transfer Function Using

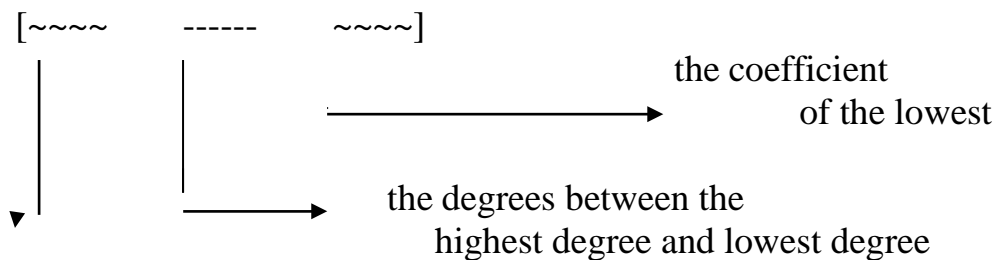
Matlab programming in control systems. **Object :**

How to deal with a transfer function and using its coefficients (num , den) in amatlab program.

### Instructions :

A) a transfer function such as  $G(S)=\frac{18(S+20)}{(S+15)(S+25)}$

the numerator of it is  $=18(S+20)$ ,so we enter it in amatlab program as  $\text{num}=18*[1\ 20]$  , where (1) is a coefficient of the S and 20 is a coefficient of  $S^0$  thus the arrangement of coefficient is as follow:



the coefficient of the highest degree of S

conv: Convolution and polynomial multiplication; for example  $C = \text{conv}(A, B)$  .

for example if we have the  $\text{num}=S^3 + 2S^2 + 5$

so we enter it in a matlab program in the form  $\text{num}=[1\ 2\ 0\ 5]$  and so on , the same thing is done with denominator so ,  $\text{den}=\text{conv}[1\ 15],[1\ 25]$  , where conv mean multiply the two brackets with each other.

### **Example :**

$$\text{If } G(S) = \frac{18(S+20)}{(S+15)(S+25)(S+0.4)}$$

the program will be as follows:

```
num=18*[1 20];  
den=conv ( conv ([1 15],[1 25]),[1 0.4]);  
G(s)=tf(num,den)
```

B)if we want to find a T.F. of a 2<sup>nd</sup> order control system by knowing its natural frequency  $\omega_n$  & damping ratio  $\zeta$  by a matlab program this could be known as follows:

### **Program:**

```
wn=2; damping=0.707;  
[num1 , den1]=ord2(wn , damping);  
G1(s)=tf(num1,den1)
```

### **Case studies**

$$1 - G(s) = \frac{s}{s^2 + 6s + 8}$$

$$2 - G(s) = \frac{(s + 3)}{(s + 4)(s + 2)(s + 7)}$$

$$3 - G(s) = \frac{9s}{s^6 + s^4 + s^2 + s}$$

$$4 - G(s) = \frac{s(s + 2)}{(s^2 + 2)(s + 5)}$$

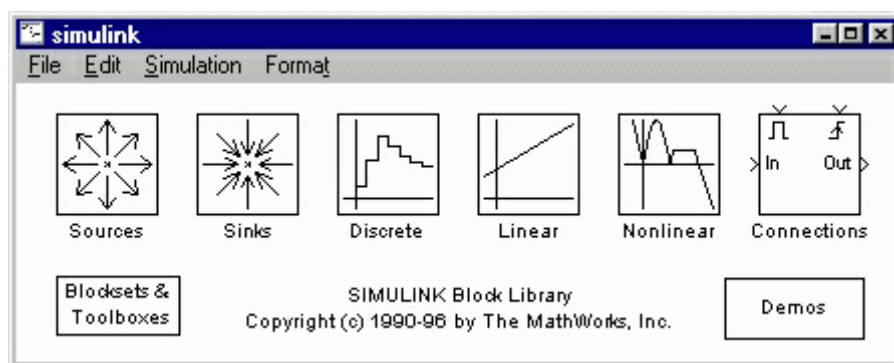
$$5 - \text{damping} = 0.4; \omega_n = 2$$

$$6 - \text{damping} = 0.2; \omega_n = 1$$

## EXPERIMENT NO.2:

# Simulink Basics Tutorial - Block Libraries

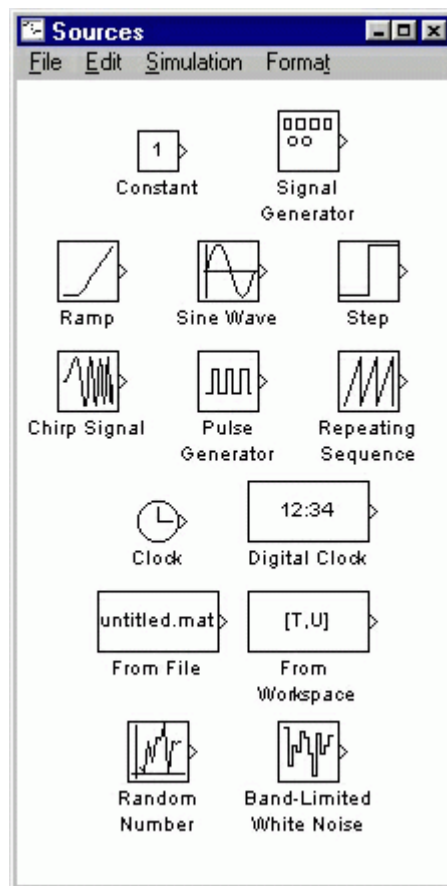
Simulink contains a large number of blocks from which models can be built. These blocks are arranged in **Block Libraries** which are accessed in the main Simulink window shown below



Each icon in the main Simulink window can be double clicked to bring up the corresponding block library. Blocks in each library can then be dragged into a model window to build a model.

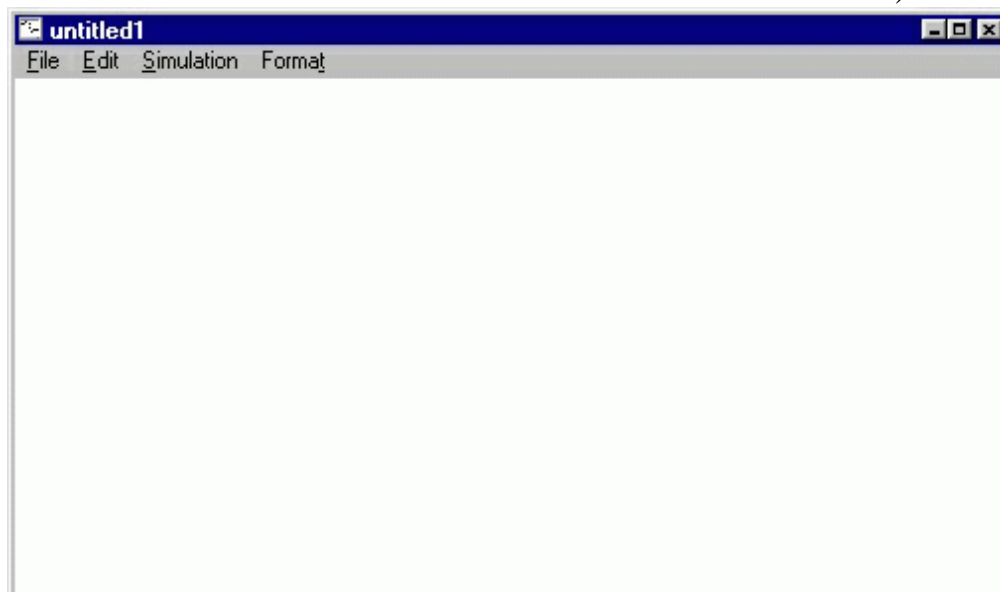
## Sources

**Source Blocks** are used to generate signals. Double-click on the **Sources** icon in the main Simulink window to bring up the Sources window.



Notice that all of the source blocks have a single output and no inputs. While parameters in each of these blocks in the library can be modified by double-clicking the block, it is best to not modify the blocks until they have been copied into a model window.

In order to examine these blocks, create a new model window (select **New** from the **File** menu in the Simulink window or hit Ctrl+N).



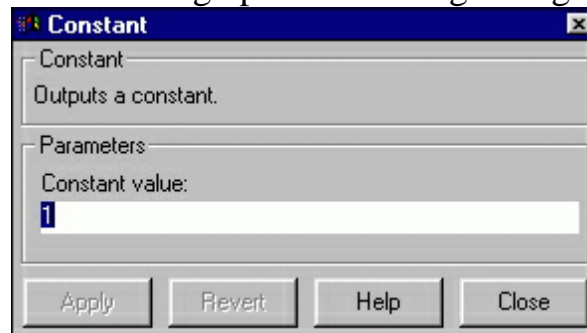
## Constant

The Constant Source Block simply generates a constant signal. The constant output value is displayed in the middle of the block, with a default value of 1.

To use this block, drag it from the Sources window into your new model window.



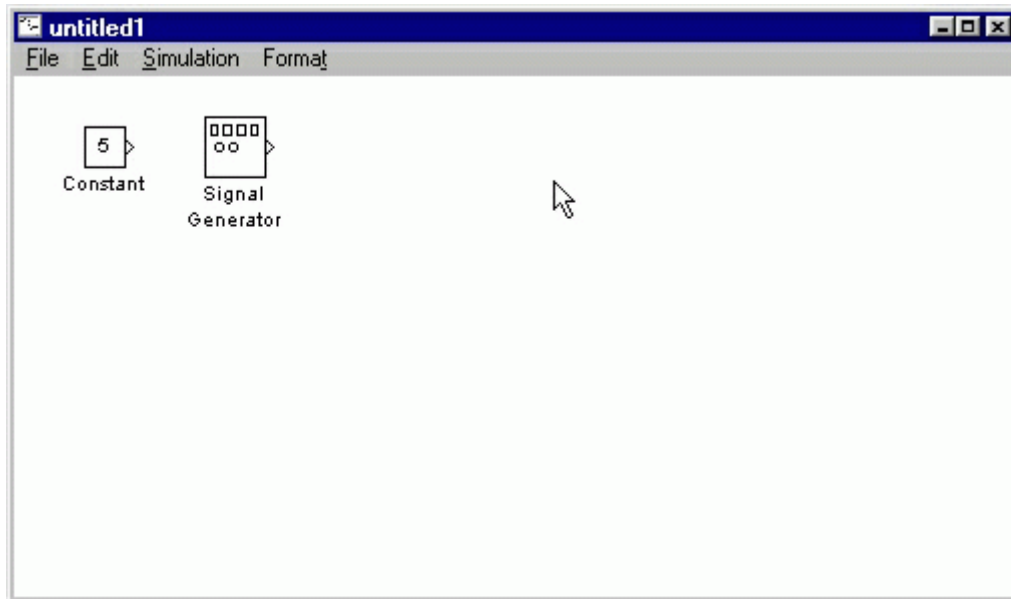
To change the constant output value, double-click on the block in your model window to bring up the following dialog box.



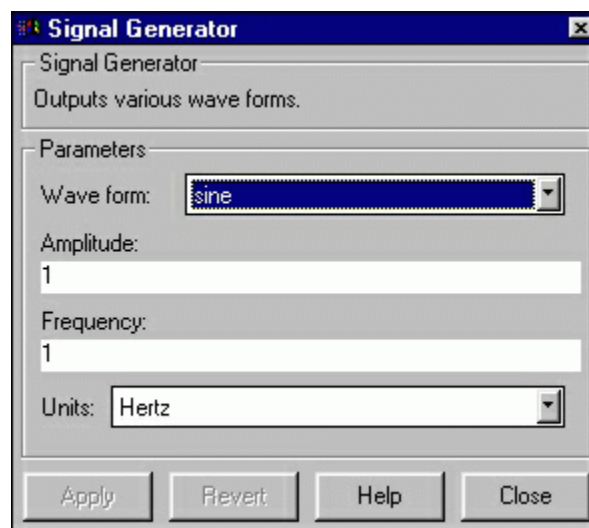
Change the constant value field from 1 to some other value, say, 5, and close the dialog box. Your model window will reflect the update by displaying a 5 in the middle of the constant block.

## Signal Generator

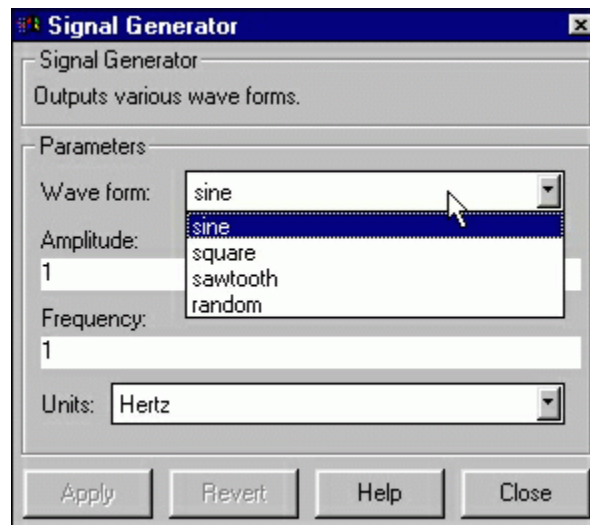
The Signal Generator Source Block is a general-purpose source which encompasses some of the other blocks' functions. It generates periodic waveforms such as sine, square, and sawtooth waves as well as a random signal.



By default, the Signal Generator generates a sine wave with an amplitude of 1 and a frequency of 1 Hz. To change this, double-click the Signal Generator in your model window to bring up the following dialog box.



The Amplitude and Frequency can be changed in this dialog box, as well as the type of waveform. To change the waveform, click on the Waveform field to bring up a list of possible waveforms.



The desired waveform can be selected from this list.

### **Ramp**

The Ramp Source Block generates a signal which is initially constant and begins to increase (or decrease) at a constant rate at a specified time. The slope, start time, and initial output can be specified.

### **Sine Wave**

The Sine Wave Source Block generates a sinusoidal signal. The Amplitude and Frequency can be specified, as well as the Phase (unlike the Signal Generator). There is a fourth parameter, the Sample Time, which can be used to force the Sine Wave Source to operate in discrete-time mode (more about [Discrete Time](#) systems in Simulink later.)

### **Step**

As described earlier, the Step Source Block generates a step function. The initial and final values can be specified, as well as the step time.

### **Chirp Signal**

The Chirp Signal Source Block generates a sinusoidal signal which scans over a range of frequencies. The initial and final frequencies as well as the scan time can be specified. The amplitude is always 1, and the chirp signal repeats itself after each frequency scan.

### **Pulse Generator**

The Pulse Generator Source Block generates a pulse train of varying duty cycle. The signal switches between 0 and the specified value starting at a particular time. The Period, Duty Cycle, Amplitude, and Start Time can be specified.



## **Repeating Sequence**

An arbitrary set of points (t,y) can be specified. These points are entered as a vector specifying the time values, and a vector specifying the corresponding output values at those times. The output is linearly interpolated between the specified time values. At the last time value, the output immediately starts over, possibly with a discontinuous transition.

## **Clock**

The Clock Source Block generates a signal equal to the current time in the simulation. This is useful when the output of a simulation is exported to MATLAB but occurs at uneven time steps. The clock's output reflects the times at which the other signals outputs occur.

## **Digital Clock**

The Digital Clock Source Block generates a strictly periodic time signal at a specified sampling interval.

## **From File**

The From File Source Block outputs a signal taken from a specified .mat file. A matrix saved in MATLAB as a .mat file will become a signal where the first row of the matrix specifies the time values. This is similar to the Repeating Sequence Source Block.

## **From Workspace**

The From Workspace Source Block is identical to the From File Source Block except the values are taken from a variable (or expression) in the MATLAB Workspace.

## **Random Number**

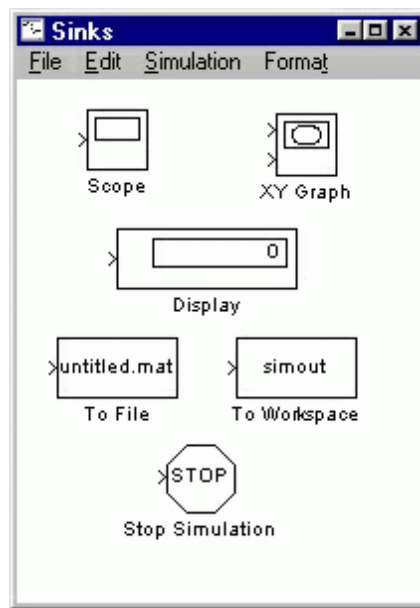
The Random Number Source Block generates a sequence of random numbers generated with the specified random number seed. Because of the seed, the same sequence can be applied to more than one simulation.

## **Band-Limited White Noise**

The Band-Limited White Noise Source Block generates a random signal which changes at a specified sample period. The strength of the signal and a random number seed can also be specified.

## **Sinks**

**Sink Blocks** are used to display or output signals. Double-click on the **Sinks** icon in the main Simulink window to bring up the Sinks window.



Notice that all of the sink blocks have inputs and no outputs. Most have a single input.

### **Scope**

The Scope Sink Block was described earlier. It is used to display a signal as a function of time.

### **XY Graph**

The XY Graph Sink Block plots one signal against another. It is useful for phase-plane plots, etc.

### **Display**

The Display Sink Block is a digital readout of a signal at the current simulation time.

### **To File**

The To File Sink Block saves a signal to a .mat file in the same way that the From File Source Block reads from a file. The sampling time can be specified, but is not necessary.

### **To Workspace**

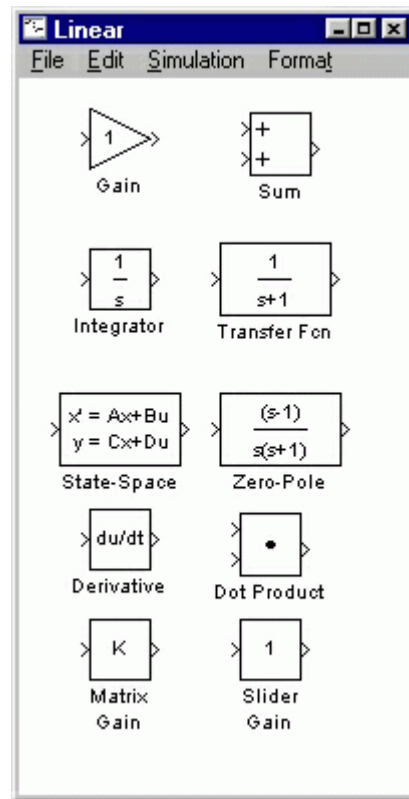
The To Workspace Sink Block stores a signal in a specified workspace variable. Unlike the To File Sink Block, the time is not saved in the variable, and must be stored separately.

### **Stop Simulation**

This is a special control block which is triggered to stop the current simulation when its input is non-zero.

## Linear

**Linear Blocks** are elements of linear continuous-time dynamic systems. Double-click on the **Linear** icon in the main Simulink window to bring up the Linear window.



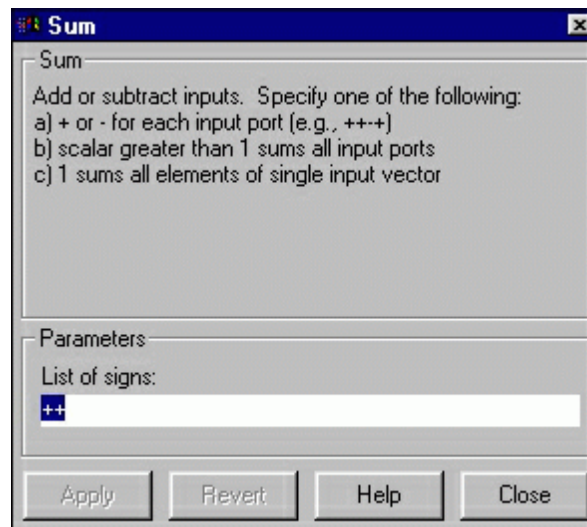
## Gain

This is a scalar or vector gain. The specified gain multiplies the input. The output is either a scalar or vector signal following normal vector-scalar multiplication rules.

## Sum

The Sum Block adds (or subtracts) two (or more) signals and outputs their sum (or difference). The two inputs must either all be scalars, or all be vectors of the same dimension. The output is the same dimension as the inputs.

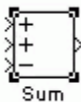
Drag this block into your model window and double click on it, bringing up the following dialog box.



By default, the Sum block adds two signals. The list of signs field represents both the number of inputs and whether to add or subtract them. To make the Sum block add two signals and subtract a third, change the list of signs to the following:

++-

Each element in the list corresponds to one of the signals. Close the dialog box. The Sum block in your model window should now have three inputs, one of which has a minus sign as shown below.



## Integrator

The output of the Integrator is the integral of the input. An initial condition can be specified, as well as saturation limits. This block is very useful for [modeling](#) systems.

## Transfer Function

Numerator and denominator polynomials can be specified to create a standard SISO LTI system transfer function.

## State Space

A, B, C, and D matrices can be specified to create a LTI state space system. Inputs and outputs may be vector signals depending on the sizes of the matrices.

## Zero-Pole

Vector lists of zeros and poles can be specified to create a transfer function. DC gain is also specified.

**Derivative**

The output is equal to the derivative of the input.

**Dot Product**

The output is equal to the dot product of two vector signals.

**Matrix Gain**

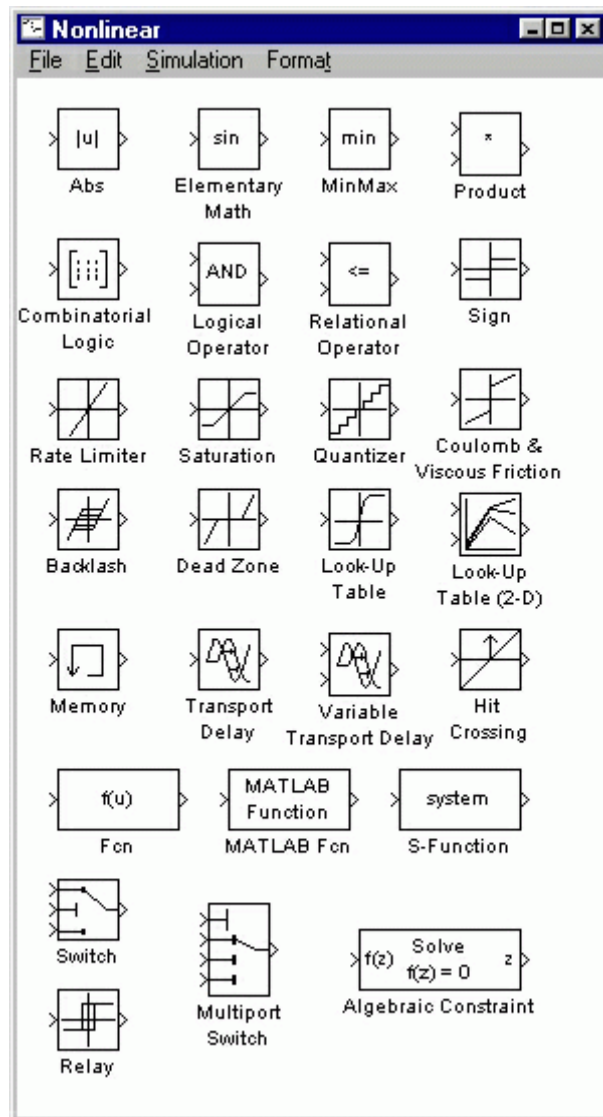
The output is equal to the input times a specified constant matrix. The size of the input and output vector signals must match the size of the matrix.

**Nonlinear**

**Nonlinear Blocks** are elements of nonlinear continuous-time dynamic systems.

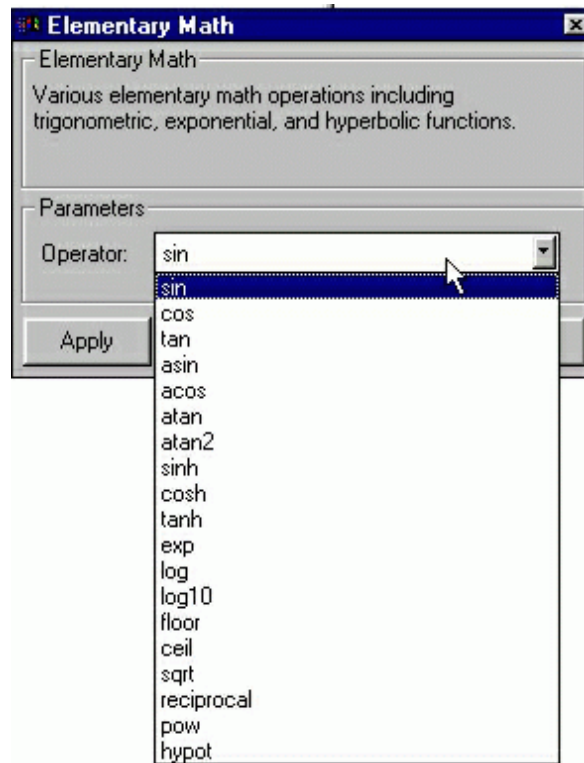
Most of these have special-purpose applications and will not be used in the tutorials. Only the most relevant Nonlinear blocks will be discussed here.

Double-click on the **Nonlinear** icon in the main Simulink window to bring up



## Elementary Math

The output of this block is a basic mathematical function applied to the input. Copy this block into your model window and double click on it. The resulting dialog box has one field, which when clicked on, give the following menu of functions.



The desired function can be selected from the list, and the choice will be displayed in the block in your model window.

### **Product**

The output is equal to the product of the inputs. The number of inputs can be specified.

### **Fcn**

Arbitrary MATLAB expressions can be represented by this block.

### **Connections**

**Connection Blocks** are used to organize and combine signals and systems. These also have special purpose applications, and only some of these will be described here. Double-click on the **Connections** icon in the main Simulink window to bring up the Connections window.

