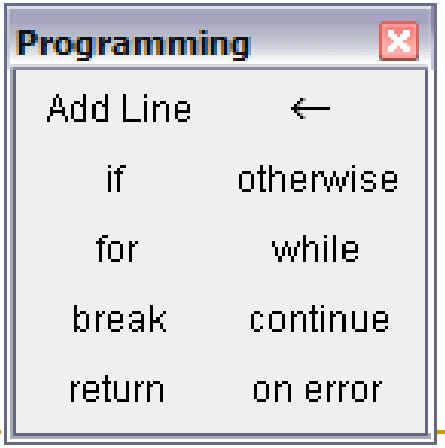
Lecture 4

Programming in MathCAD

MathCAD Program

- Multi-step function (three parts)
- 1st part: define a function name
  - which will become the program name
  - used to refer to the program whenever needed
- 2nd part: parameter list
  - list all the variable information that must be known before the program can do its jobs
- 3rd part: assignment operator (:=)

- On right side of the assignment operator add two or more lines using the ***Add line*** from Programming Toolbox or by] key
- Local variables (i.e. variables that are used inside the body of a program are assigned using ← instead of equal to sign
- ← can be given either from Programming Toolbox or by pressing { key
- Click *Add line* button as many times as you need to have more lines



Calculate the area of a circle

$$A_{circle}(diameter) := \left| \begin{array}{l} radius \leftarrow \dfrac{diameter}{2} \\ \\ area \leftarrow \pi \cdot radius^2 \end{array} \right.$$

$$A_{circle}(4) = 12.566$$

$$A_{circle}(5cm) = 1.963 \times 10^{-3}\, m^2$$

Use more than one parameter as input

$$\text{Cylinder}(r,\ h) := \left\| \begin{array}{l} x \leftarrow r \\ y \leftarrow h \\ \text{volume} \leftarrow \pi \cdot x^2 \cdot h \end{array} \right.$$

$$\text{Cylinder}(2,\ 4) = 50.26$$

- Local variables can only used inside the program, they loose their values when the program terminates
- Cannot assign values to the worksheet variables from within a program
- By default, the last value assigned in a program is the output of the program
- Can use return statement to return (output) multiple values

If statement

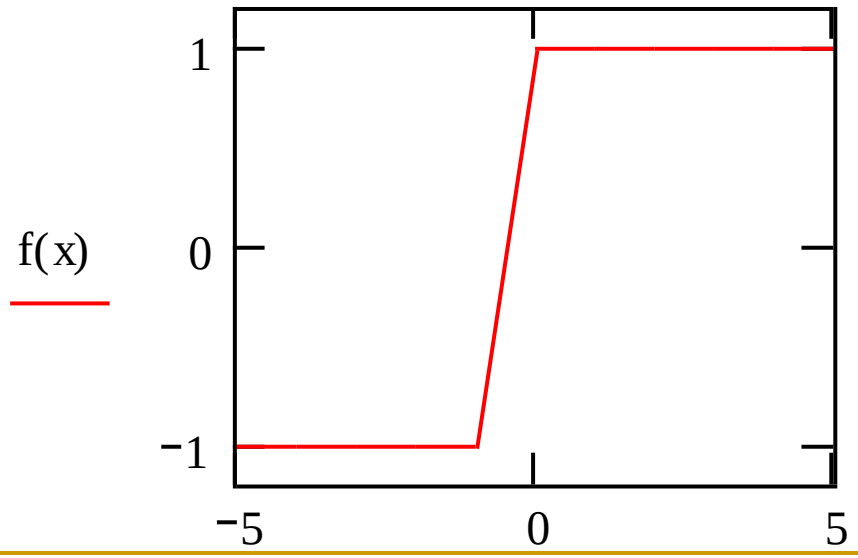
- Click the ***if*** button or press [**Shift** + **]**]. Do *not* just type the word "if"
- In the right placeholder, type a boolean expression
- Click the ***Add line*** button to insert placeholders for additional statements if necessary
- Click in the remaining placeholder and click the ***otherwise*** button. Do *not* just type the word "otherwise"

Example of If statement

$$f(x) := \begin{cases} 1 & \text{if } x \geq 0 \\ -1 & \text{otherwise} \end{cases}$$

$f(8) = 1 \qquad f(-6) = -1$

$x := -5..5$



For Loop

- Use For loop when you know exactly how many times you want to execute the loop body
- Click ***for*** button or press [Ctrl+"]. Do not type the word "for"
- In the placeholder to the left of the  , enter the iteration variable
- In the placeholder to the right of the  , enter the range of values to be taken by the iteration variable
- Click the ***Add line*** button to insert placeholders for additional statements if necessary

Sum of integers 1 to 15

$$\text{sum}(n) := \left| \begin{array}{l} s \leftarrow 0 \\ \text{for} \quad i \in 1..n \\ \quad s \leftarrow s + i \end{array} \right.$$

$$\text{sum}(15) = 120$$

$$\text{sum}(300) = 4.515 \times 10^{4}$$

Return statement

- Use return statement to override the default and specify a different value to be returned by the program
- Use to return multiple values from the program as an array

$$\text{sum}(n) := \left| \begin{array}{l} s \leftarrow 0 \\ \text{for } i \in 1..n \\ \quad s \leftarrow s + i \\ \text{return } i \end{array} \right.$$

$$\text{sum}(15) = 15$$

$$\text{Circle}(\text{diameter}) := \left| \begin{array}{l} \text{radius} \leftarrow \dfrac{\text{diameter}}{2} \\ \text{area} \leftarrow \pi \cdot \text{radius}^2 \\ \text{perimeter} \leftarrow 2 \cdot \pi \cdot \text{radius} \\ \text{return} \begin{pmatrix} \text{area} \\ \text{perimeter} \end{pmatrix} \end{array} \right.$$

$$\text{Circle}(5) = \begin{pmatrix} 19.635 \\ 15.708 \end{pmatrix}$$

While loop

- If you don’t know exactly how many times you want to execute the loop body, use while loop
- While loop is keep on executing the loop until the given condition is met
- Click ***while*** button or press [Ctrl+]]
- In the placeholder to the right of ‘while’, type a boolean expression

```
demo(start) := | y ← start
               | while y < 200
               |     y ← y + 5
               | y
```

demo(2) = 202 demo(6) = 201

```
demo(start, end) := | x ← start
                    | while x ≤ end
                    |     x ← x + 5
                    | return x
```

demo(2, 200) = 202 demo(6, 200) = 201

demo(2, 50) = 52 demo(6, 50) = 51

Define an n by n identity matrix

$$ORIGIN := 1$$

$$I(n) := \left| \begin{array}{l} \text{for } i \in 1..n \\ \quad \text{for } j \in 1..n \\ \quad\quad \left| \begin{array}{l} M_{i,j} \leftarrow 1 \quad \text{if } i = j \\ M_{i,j} \leftarrow 0 \quad \text{otherwise} \end{array} \right. \\ \text{return } M \end{array} \right.$$

$$I(3) = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

Add Line:]

Inserts a new line into a programming block or creates a new programming block.

Local Definition ← : {

Assignment equal for programming blocks. This operator defines a variable with local scope.

if: }

Conditional statement. Computes the assignment if the condition is true.

return: Ctrl |

Returns a value or an array of values to the function statement.

otherwise: Ctrl }

Used in conjunction with the if statement to assign a value if the condition is false.

for: Ctrl “

Unconditional loop execution. Used to perform execution repeatedly a predefined number of times.

while: Ctrl]

Conditional loop execution. Used to perform execution repeatedly while an imposed condition is true.

break: Ctrl {

Used to halt the execution of for or while loops when a condition is true.

```
Summation(N) := | a ← 0
                | n ← 0
                | while n < N
                |     | n ← n + 1
                |     | a ← a + n
                |     | break if n > 99
                | return a
```

Summation(50) = 1275

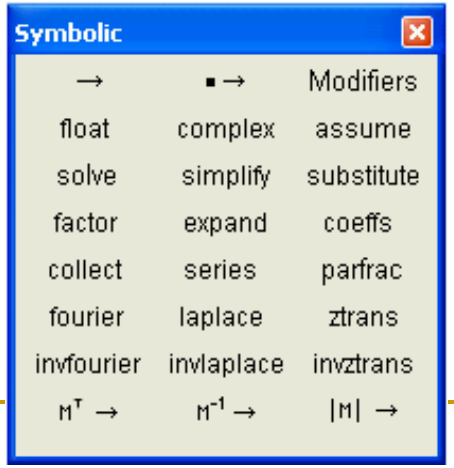
Summation(100) = 5050

Summation(120) = 5050

Symbolic Operations

- Mathcad includes symbolic operators that allow a number of algebraic manipulations to be performed over expressions without the need to evaluate numeric values.

- The symbolic toolbar below provides a list of the available operators



Symbolic Operations

Expand:

The expand operator is used to develop a factorized expression.

$$(x-7)\cdot(x-2)\ \text{expand},x\ \rightarrow x^2-9\cdot x+14$$

Symbolic Operations

Factor:

The factor operator is used to factorize expanded expressions.

$$x^2 - 9 \cdot x + 14$$

Select the expression and click Factor from the Symbolics top menu:

$$(x - 7) \cdot (x - 2)$$

$$x^2 - 7 \cdot x + 10 \text{ factor} \rightarrow (x - 2) \cdot (x - 5)$$

Symbolic Operations

Substitute:

The substitute operator replaces a variable by another in the expression.

$$x^3 - 2\cdot x^2 - 3\cdot x + 4 \text{ substitute}, x = y \rightarrow y^3 - 2\cdot y^2 - 3\cdot y + 4$$

Symbolic Operations

Solve:

The substitute operator replaces a variable by another in the expression.

$$x^2 - 9\cdot x + 14 \,\text{solve}, x \rightarrow \begin{pmatrix} 2 \\ 7 \end{pmatrix} \qquad -2\cdot x^2 + 3\cdot x + 4 \,\text{solve} \rightarrow \begin{pmatrix} \frac{\sqrt{41}}{4} + \frac{3}{4} \\ \frac{3}{4} - \frac{\sqrt{41}}{4} \end{pmatrix}$$

This is another way to solve quadratic equation

Symbolic Operations

Simplify:

The simplify operator can be used to combine expressions with a common denominator.

$$\frac{a}{x-3}+\frac{b}{x-4}\ \text{simplify}\ \rightarrow \frac{(a\cdot x-4\cdot a+b\cdot x-3\cdot b)}{(x-3)\cdot(x-4)}$$

Symbolic Operations

Mathcad symbolic integration and differentiation capabilities are one of its most powerful features.

$$\int \left(x^2 - 3\cdot x + 6\right) dx \rightarrow \frac{1}{3}\cdot x^3 - \frac{3}{2}\cdot x^2 + 6\cdot x$$

Differentiation can also be performed the same way.

$$\frac{d}{dx}\left(3\cdot x^3 - 4\cdot x^2 + 2\cdot x + 6\right) \rightarrow 9\cdot x^2 - 8\cdot x + 2$$

Numerical Techniques

Numerical integration can be directly performed with the definite integral operator.

$$\int_{-1}^{2} e^{-x^2}\,dx = 1.629$$

$$\int_{0}^{1} \cosh(x)^2\,dx = 1.407$$