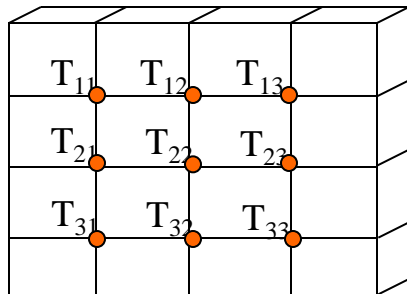# Lecture 2:
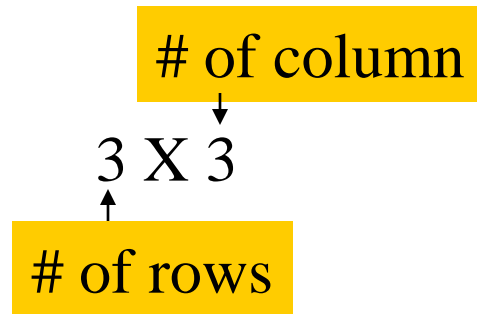
WORKING WITH MATRICES

MathCAD's Matrix Definitions

⌘Matrix: collection of numbers (elements) that are related in some way

⌘Examples: For holding data sets (temperature, time); (temperature, position),etc.

$$T = \begin{bmatrix} T_{11} & T_{12} & T_{13} \\ T_{21} & T_{22} & T_{23} \\ T_{31} & T_{32} & T_{33} \end{bmatrix}$$

# of column

3 X 3

# of rows

MathCAD definitions

❖Vector has only one row or column

❖Matrix has at least two rows or two columns

❖Array is either a matrix or a vector

$$T = \begin{bmatrix} T_1 \\ T_2 \\ T_3 \end{bmatrix} \qquad t = \begin{bmatrix} t_1 \\ t_2 \\ t_3 \end{bmatrix} \qquad A = \begin{bmatrix} T_1 & t_1 \\ T_2 & t_2 \\ T_3 & t_3 \end{bmatrix}_{3x2}$$

- *Array Origin*: MathCAD refers to the first element in a vector or matrix as element zero.
- For example:

$$A = \begin{bmatrix} 12 & 15 & 17 \\ 23 & 25 & 29 \end{bmatrix} \qquad \begin{aligned} A_{00} &= 12 \\ A_{01} &= 15 \end{aligned}$$

- Maximum Array Size:
  - No more than 100 elements per array.
 - No more than 8×10^6 in all arrays.

Initializing an Array

⌘ Methods:

⌃ Type in the values from the keyboard.

⌃ Read the values from a file: Text or ASCII files are used to move data between programs)

☒ Import a text file into mathCAD as a matrix: C:=READPRN("A: mydata.txt")

☒ Export from mathCAD use WRITEPRN("A:mydata.txt"):=C

⌃ Compute the values by using a function or range variable. The range variable is defined as i := 0..3 (.. in mathCAD by typing ;).

⌃ Copy and paste from another Windows program.

Type in from the keyboard

⌘ Type the name of the matrix then type :=

⌘ Choose **Insert/Matrix** from menu *OR*

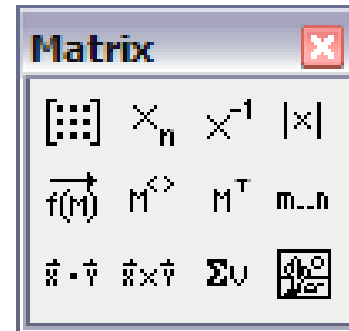⌘ Choose Matrix from Matrix Toolbox *OR*

⌘ Use [Ctrl-M] from keyboard
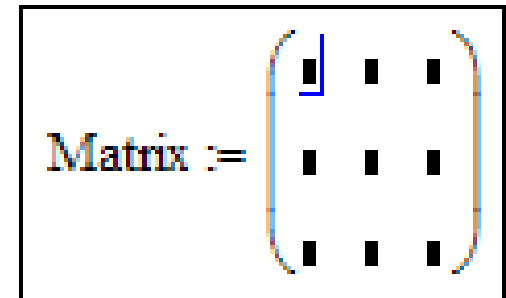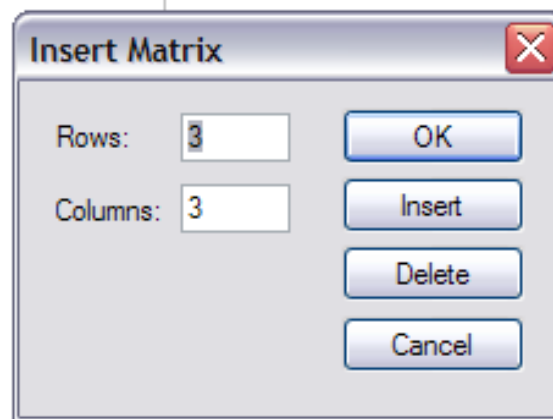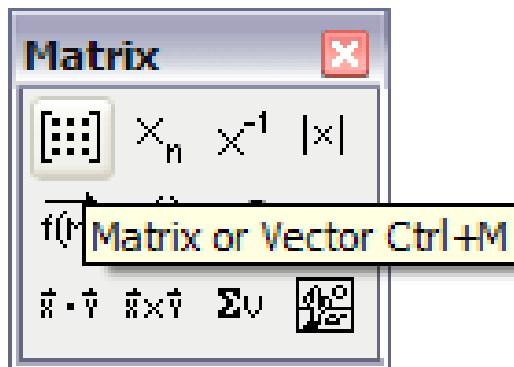
Using range variable

- ⌘ Type the range variable
  - ⌄ Example: i = 0 to 10
  - ⌄ Use [;] for .. OR
  - ⌄ Use Matrix Toolbox
- ⌘ Calculate the elements of the matrix using the range variable
  - ⌄ Use index subscript

Matrix

$$i := 0..5$$

$$\text{Matrix}_i := 4 \cdot i + 5$$

index subscript

$$\text{Matrix} = \begin{pmatrix} 5 \\ 9 \\ 13 \\ 17 \\ 21 \\ 25 \end{pmatrix}$$

Using a function

⌘Define a function of two variables

⌘Call matrix() function to create the matrix

$$f(\text{row}, \text{column}) := \text{row}^2 + 4.\text{column}$$

$$\text{Matrix} := \text{matrix}(2, 3, f)$$

function

row

column

$$\text{Matrix} = \begin{pmatrix} 0 & 4 & 8 \\ 1 & 5 & 9 \end{pmatrix}$$

Reading from a file

$$\text{Matrix} := \begin{pmatrix} 1 & 2 & 3 & 4 & 5 \\ 6 & 7 & 8 & 9 & 0 \\ 1 & 2 & 3 & 4 & 5 \\ 6 & 7 & 8 & 9 & 0 \end{pmatrix}$$
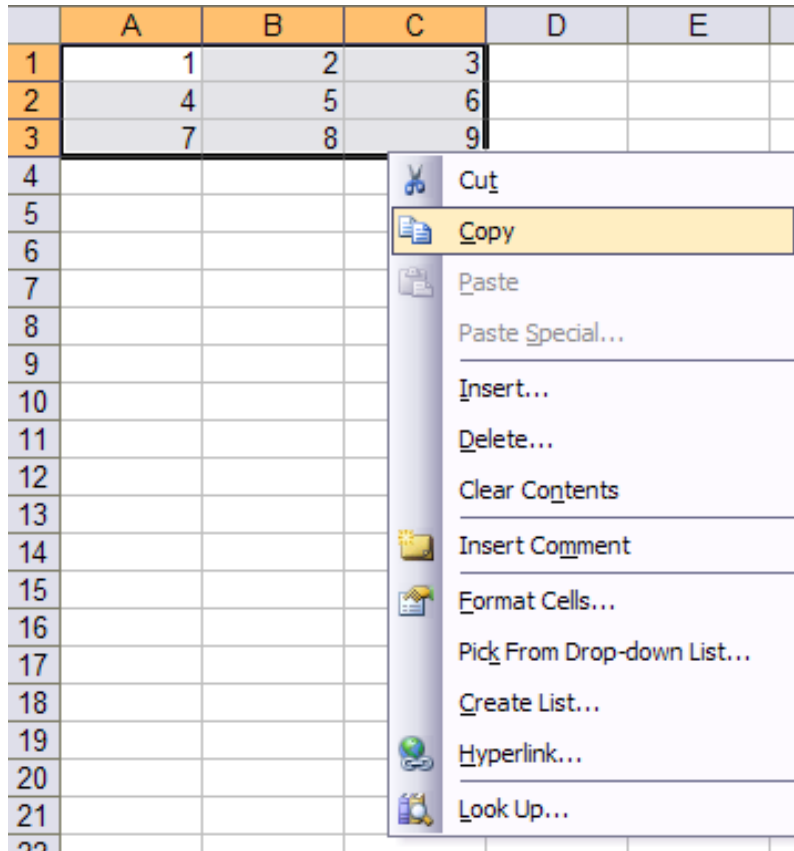
$$\text{WRITEPRN}\left(\text{"C:\textbackslash data.txt"}\right) := \text{Matrix}$$

$$C := \text{READPRN}\left(\text{"C:\textbackslash data.txt"}\right)$$

$$C = \begin{pmatrix} 1 & 2 & 3 & 4 & 5 \\ 6 & 7 & 8 & 9 & 0 \\ 1 & 2 & 3 & 4 & 5 \\ 6 & 7 & 8 & 9 & 0 \end{pmatrix}$$
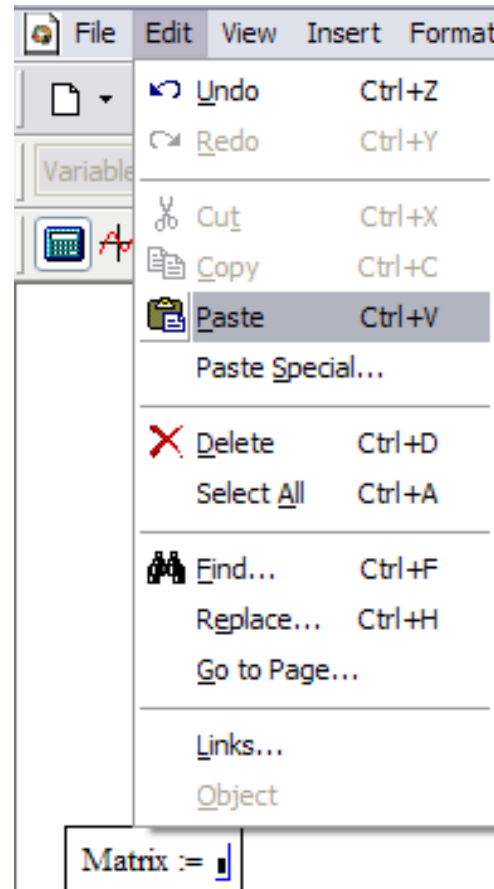
Copying from other windows program

⌘Copy the data from Excel

$$\text{Matrix} := \begin{pmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{pmatrix}$$

Units in Matrix Elements

⌘ Elements have the same units

$$t = \begin{bmatrix} t_1 \\ t_2 \\ t_3 \end{bmatrix} \ \min$$

⌘ Elements don't have the same units

$$t = \begin{bmatrix} t_1 \min \\ t_2 \min \\ t_3 \sec \end{bmatrix}$$

Creating an Identity Matrix

⌘ID:=identity (5)

$$M = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

Modifying an Array

⌘ To join arrays side to side: [augment(A,B)]

⌘ To join arrays one on top of the other:[stack(A,B)]

⌘ Inserting a row or a column:

⬠ 1)click on the row immediately above where you want the new row to be inserted.

⬠ 2)Bring up the insert Matrix box by typing [Ctrl-M].

⬠ 3)Indicate the number of rows.

⬠ 4)Press insert

Inserting a row

$$\text{Matrix} := \begin{pmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{pmatrix}$$

Insert Matrix

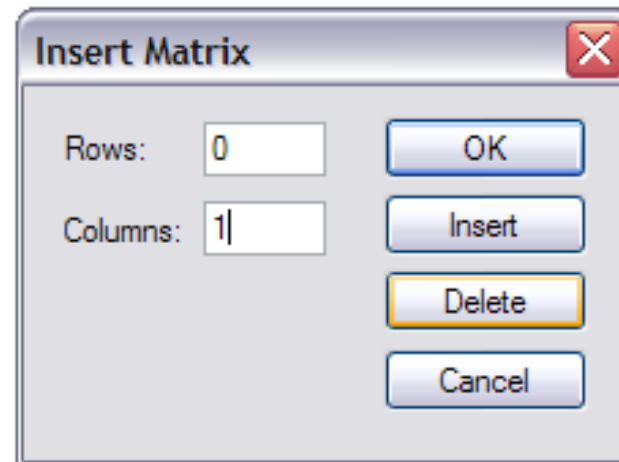|	
Rows:	1
Columns:	0

OK
Insert
Delete
Cancel

$$\text{Matrix} := \begin{pmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ \blacksquare & \blacksquare & \blacksquare \\ 7 & 8 & 9 \end{pmatrix}$$

Deleting a column

⌘ Select an element in the column to be deleted

$$\text{Matrix} := \begin{pmatrix} 1 & 2 & 3 & 4 & 5 \\ 0 & 9 & 8 & 7 & 6 \\ 2 & 3 & 4 & \underline{5} & 6 \\ 9 & 8 & 7 & 6 & 5 \end{pmatrix}$$

Insert Matrix

Rows: 0   OK

Columns: 1   Insert

Delete

Cancel

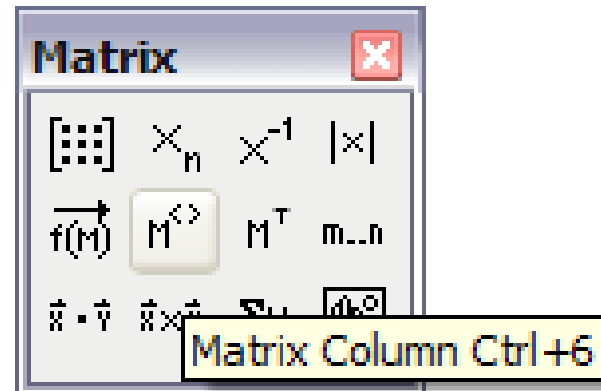$$\text{Matrix} := \begin{pmatrix} 1 & 2 & 3 & 5 \\ 0 & 9 & 8 & 6 \\ 2 & 3 & 4 & 6 \\ 9 & 8 & 7 & 5 \end{pmatrix}$$

Selecting a Single Column

- MathCAD allows you to take a single column vector of a multicolumn array.
- $M^{<>}$
- $Temp := C^{<0>} \cdot K$
- $Time := C^{<1>} \cdot min$

Matrix

Matrix Column Ctrl+6

$$Matrix := \begin{pmatrix} 1 & 2 & 3 & 5 \\ 0 & 9 & 8 & 6 \\ 2 & 3 & 4 & 6 \\ 9 & 8 & 7 & 5 \end{pmatrix}$$
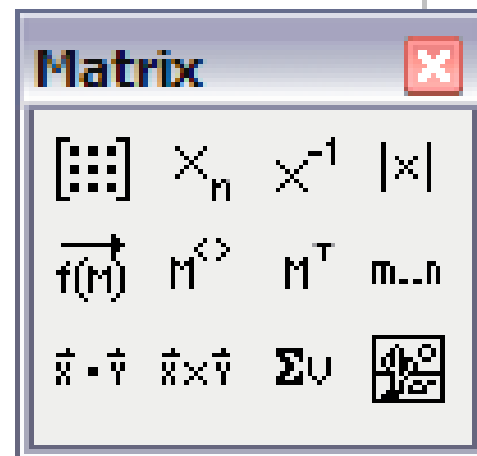
$$time := Matrix^{<0>} \cdot min$$

$$time = \begin{pmatrix} 60 \\ 0 \\ 120 \\ 540 \end{pmatrix} s$$

Array Operations:

❖ Addition and Subtraction (A+B)

❖ Multiplication (A.B) [Shift-8]

❖ Element by Element Multiplication: $f(\vec{M})$

❖ Transposition: interchange row and column elements: M^T

❖ Inversion: M^{-1} [Shift-6]

❖ Determinant: $|M|$

Arrays Functions

- max(C)   maximum value of matrix C
- min(C)   minimum value of matrix C
- rows(C)   number of rows in matrix C
- cols(C)   number of columns in matrix C
- last (a)   index of last element of vector a
- length(a) number of elements in vector a
- sort(a)   arranges elements of vector a in increasing order
- reverse(a) arranges in decreasing order

Examples:

- Find out whether the system of simultaneous equations has a unique solution. If yes, find the solution.
  - If the determinant of the coefficient matrix is nonzero, then the system has a unique solution
  - $2x_1 + 3x_2 + x_3 = 12$
  - $x_1 + 4x_2 + 7x_3 = 16$
  - $3x_1 + 7x_2 + 7x_3 = 18$

$$\text{coefficient} := \begin{pmatrix} 2 & 3 & 1 \\ 1 & 4 & 7 \\ 3 & 7 & 7 \end{pmatrix}$$

$$\left| \text{coefficient} \right| = -5$$

$$\text{constant} := \begin{pmatrix} 12 \\ 16 \\ 18 \end{pmatrix}$$

$$\text{solution} := \text{coefficient}^{-1} \cdot \text{constant}$$

$$\text{solution} = \begin{pmatrix} 34 \\ -22 \\ 10 \end{pmatrix}$$