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Introduction to Mathematica

This workshop is designed to enhance comprehension of how to use Mathematica to perform various mathematical operations.

1. Learning Objectives

- How to Download or Access Mathematica
- A Basic Intro to Mathematica
- Managing Data
- How to use Key Built-in Functions
- Solving Algebraic and Calculus Operations
- Performing Matrix Operations

2. Availability & Accessing Mathematica

American University allows all its students to have free access to Mathematica. There are three principal ways in which American University students could access Mathematica.

- The Virtual Computing Lab
- Campus Labs
- Free Download

To download the student version

- Go to user.wolfram.com and click "Create Account"

Fill out form using a @american.edu email, and click "Create Wolfram ID"

Check your email and click the link to validate your Wolfram ID.

- Fill out this form to request an Activation Key

Click the "Product Summary page" link to access your license

Click "Get Downloads" and select "Download" next to your platform

Run the installer on your machine, and enter Activation Key at prompt.

3. Introduction to Mathematica

The basic file type in Mathematica is called a notebook and it has an extension .nb. However, Mathematica output can be saved in multiple formats. (PDF, Latex, Html, and etc...). A Mathematica notebook is a very versatile and dynamic file type that allows both textual and math content. Users can design ornate typeset presentations using the rich editing abilities of the notebook which include titles, subtitles, bullets, sections, multiple font families etc. Each notebook file is composed of multiple cells. A cell is designed to be a self-contained unit. There are two basic types of cells – math cells and text cells. Users are encouraged to type all text like titles (e.g. Homework 10), authors, dates and paragraphs of explanations in text cells. All of the mathematical content should be in *Mathematica input* cells (math cells). Each cell is delineated by a horizontal line which is visible if you hover with the mouse over it. At the left-most end of the line there is a "+" sign where the user can select the type of the cell (Mathematica input or a plain text cell for example). Some of the rich properties of text cells can be explored in the *Format* menu. For example, all the different types of text cells can be found in *Format -> Style*. In addition, the *Format* menu has quite a few features that will make your notebooks look professional (explore the *Stylesheet* options).

Mathematical operations are done in Mathematica input cells or math cells. **The easiest way to evaluate an expression is to type it in math input cell and press Shift+Enter at the end.** This will result in the creation of a new *output* cell immediately after the original input cell with the answer to the problem. You should keep in mind that simply pressing enter doesn't evaluate an expression nor does it move the cursor to another cell. Instead, pressing enter moves the cursor to a new line **within the same cell**. This means that several expressions can reside in the same cell and Shift+Enter will evaluate **all** of them. This feature is sometimes useful for more complex operations.

3.1 Mathematica Tabs

The File Tab, allows you to create new documents, exports output into various formats, save, and print Mathematica output.

The Edit Tab allows you to set preferences, edit texts, and check spelling.

The Format Tab allows you to format the document to your likings. If you want add a title page, section, subsection, ect... You can also use the format tab to make changes on the font size, and text color of your notebook.

3.2 Palettes

Palettes are shortcuts that allow users to conveniently write equations, mathematical functions, and edits their notebooks.

The Classroom Assistant

Another useful feature of Mathematica is the Classroom Assistant and you can find it at *Palettes -> Classroom Assistant*. The Classroom Assistant is a graphical user interface to the most popular features of Mathematica including mathematical operations, navigations within the document, formatting, typesetting and others. It is a helpful tool for beginners so we recommend that you keep it open in your first experiments with Mathematica, but one should not rely only on it at the expense of learning the language itself. Everything that can be done through the Classroom Assistant can be done with commands in the notebook itself!

3.3 Managing Data

- You may be interested to know What type of data can be imported into Mathematica?

\$ImportFormats

- Check to see your current path

\$ Path

- Ok now set correct the directory from which you are working from today,

```
SetDirectory["J:\\CLASSES\\RSG\\Workshops\\Workshop \\Materials\\Mathematica"]
```

- I have a file saved a csv file saved in directory(mathematica_sample_data.csv), lets import the data, name the data as sampledata

```
sampledata = Import["mathematica_sample_data.csv"]
```

- Now Let's Make it look nice by forming a nice table,

```
TableForm[sampledata]
```

- Now Let's say we are only interested in plotting Nominal GDP Growth over time, How do we do this ? we can look at what column we are interested to plot. In this case, it would be column 1 and 2. Put time on the x Axes and Nominal GDP on the y-Axes.

ListPlot[sampledata[[All, {1, 2}]]]

- What if we want to do a scatterplot of nominal GDP and money growth? We would want to use column 3 and 2.

ListPlot[sampledata[[All, {3, 2}]]]

3.4 The Basics

- Parenthesis [group arithmetic expressions]

Example 1:

(3/5) + 1

- Braces [denote a list or a set]

A={a,b,c}

B={b,c,d}

Example 2: Let's take the intersection of set A and B

AEscinterEscB

Example 3: Let's take the union of set A and B

AEscunEscB

- Defining a Function

Brackets [to indicate the argument of a function]

f [Denotes functional form]

:= [Needed to define a function]

Example 4: Lets define a basic function that performs a recursive factorial operation

```
recursivefactorial=f[n_] := n*(n-1)!
```

```
f [5]
```

- Expanding, simplifying, taking apart, putting together, and factoring expressions,

```
Simplify[((x+y)2 (x+y))/(5x+y)]
```

```
Expand[((x+y)2 (x+y))/(5x+y)]
```

```
Apart[((x+y)2 (x+y))/(5x+y)]
```

```
Together[((x+y)2 (x+y))/(5x+y)]
```

4. Key Built-in Functions

- N [returns the numerical value of an expression]

Example 1: To avoid getting a fraction as a result, you can use

```
N [((3/5)+1)]
```

- % [allows you to call the previous operation]

Example 2:

Let's Call the previous results,

```
%
```

- /. [is used to substitute expressions into other expressions]

Example 3:

Input the following expression,

$$y = 5(x^2)$$

Substitute the following value for $x=(z+\sqrt{3 + \pi})$ into y ,

$$y /. x \rightarrow (z + \text{Sqrt}[3 + \text{Pi}])$$

- Generating basic 2D or 3D plots

Example: 4

```
graph1=Plot[-5 x^3+2,{x,0.1` ,1.8}]
```

```
graph2=Plot3D[x^2+y^2,{x,.01,.02},{y,.03,.02}]
```

- Clearing values within variables

Example: 5: Lets clear the values or expressions associated with the variable y

```
Clear[y]
```

- Solving basic equations

Example 6:

Solve the following equation for x ,

$$x^2 - 4x = 5$$

Solve the above equation in Mathematica in the following manner,

```
Solve[x^2-4x==5]
```

- Solving differential equations

Example 7:

Solve the following first order differential equation,

$$\frac{dy}{dx} = 2x + 5$$

In Mathematica this first order differential equation can be solved in the following manner,

DSolve[y'[x]==2x+5, y[x], x]

- Integrate [Allows to solve an integral]

Example 8:

Solve the following integral,

$$\int (\cos(x) + x) dx,$$

Integrate[Cos[x]+x, x]

Solve the following integral,

$$\int_0^{\pi/2} \cos x \, dx$$

Integrate[Cos[x],{x,0,Pi/2}]

- Solving Derivatives

Example 9:

Consider the following expression,

$$e^{x^2}$$

Take the derivative with respect to x,

D[E^(x^2), x]

5. Linear Algebra

5.1 Defining a Matrix

Control comma to specify different columns.

Control enter to specify rows.

Otherwise use braces {} to enter each rows.

Define the following two square matrices in Mathematica,

$$A = \begin{bmatrix} -10 & 20 & 30 \\ 50 & 60 & 70 \\ 80 & 90 & 100 \end{bmatrix} \quad ; \quad B = \begin{bmatrix} 20 & 30 & 40 \\ 50 & 60 & 70 \\ 80 & 90 & 30 \end{bmatrix}$$

$$A = \{\{-10, 20, 30\}, \{50, 60, 70\}, \{80, 90, 100\}\}$$

$$B = \{\{20, 30, 40\}, \{50, 60, 70\}, \{80, 90, 30\}\}$$

- To denote all matrices in matrix form,

`MatrixForm[A]`

`MatrixForm[B]`

- Define an Identity matrix,

`MatrixForm[IdentityMatrix[100]]`

- Define a Diagonal Matrix,

`MatrixForm[DiagonalMatrix[{a, b, c, d, e, f, g, h, i, j, k}]]`

- Define a random vector

`F = MatrixForm[RandomSample[Range[1000], 3]]`

5.2 Matrix Operations

- Adding two matrices,

`MatrixForm[A + B]`

- Multiplying two matrices using the dot product,

`MatrixForm[A.B]`

- Taking the Inverse of a matrix

`MatrixForm[Inverse[A]]`

- Transposing a matrix

`MatrixForm[Transpose[A]]`

- Finding the determinant of matrix

`Det[A]`