MATH7501 Practical 1, Semester1 -2021

Topic: Basic Mathematica Usage

Author: Aminath Shausan
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Pre-Tutorial Activity

- Students must have downloaded **Wolfram Mathematica** following the link provided on MATH7501 Blackboard page

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Plan

- Understand how to format cells in Wolfram Notebook
- Learn three main methods to enter calculations
- Learn how to compute basic calculations
- Learn how to plot basic graphs
- Learn how to produce interactive models

How this Tutorial will Run

- Tutor demonstrations
- Student tasks to complete during the tutorial

Mathematica Notebook Formatting & Styling

1) What is Mathematica?

- Mathematica integrates symbolic and numerical calculations , graphics and visualization , programming , documentation , and dynamic interactivity into one big ensemble
- It is used in many fields, including science, engineering, mathematics, computing, and data science
- Mathematica uses Wolfram Language

2) What is a Wolfram Notebook?

- (Task) Open a New Notebook in Mathematica
- A Wolfram notebook allows you to organise everything you do in Mathematica in a structured document including texts, executable codes, dynamic graphics, user interfaces, and more
- Notice a blinking cursor. You can start typing right away. Notice the bracket that appears along the right side of the notebook in line with what you just typed. This bracket shows the extent of the **cell**
- Cells are the basic structures of a Wolfram notebook.
- **Rule**: use 'Shif+Enter' to evaluate content of an Input cell.

3) Three Main Methods to Format a Text Cell

Method 1: using the cell insertion assistant (Click '+' sign on the courser > Other Style of Text)
Method 2: using the Menu bar (Format > Style)
Method 3: using keyboard shortcuts ('Command/Alt + number', number = 1, to 9)

- (Task) Create a Title cell using cell insertion assistant. Type "MATH7501, Prac 1, Sem 1-2021"
- (Task) Create a Subtitle cell using Menu bar. Type "Basic Mathematica Usage"
- (Task) Create a Section cell using Keyboard shortcut (Command/Alt+5'). Type "Section 1: Entering Calculations"
- (Task) Create a Subsection cell. Type "1.1: Free-Form Input"
- (Task) Create a Subsection cell. Type "1.2: wolfram Language"
- (Task) Create a Subsection cell. Type "1.3: Palette"

1. Entering Calculations

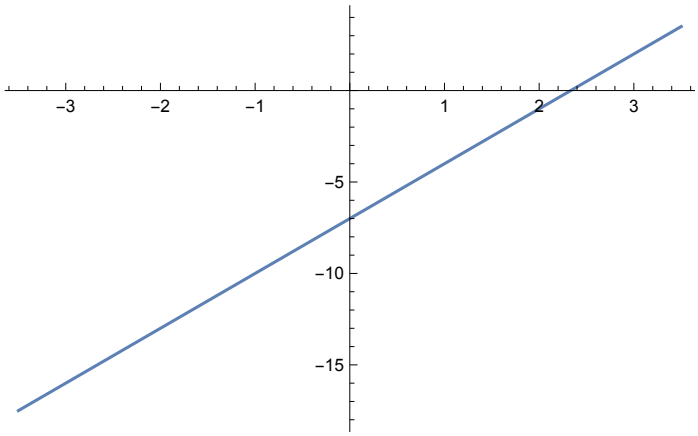
1.1 Free-Form Input

- lets you enter commands using plain English language
- To create a Free-Form Input cell,
  - click '=' sign on keyboard Or
  - Cell Insertion assistant (Click '+' sign courser on the left of a new cell > Free-Form Input)
- (Task) Type "graph $y = 3x - 7$" . Press Shift+ Enter

In[•]:=
graph y = 3 x –7

```
Plot[3 * x - 7, {x, -3.5, 3.5}]
```

Out[•]=

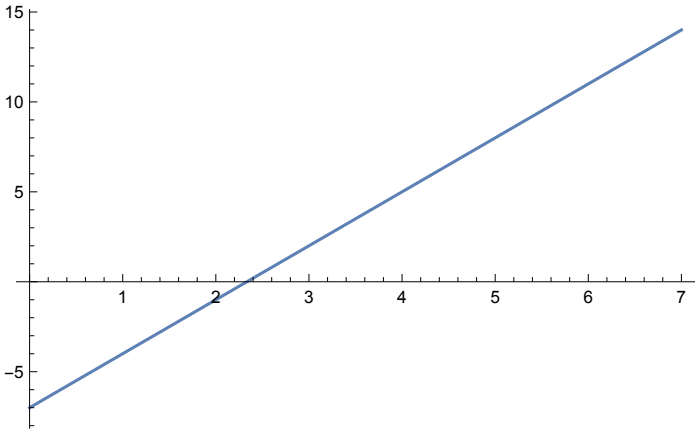


1.2 Wolfram Language

- gives you flexibility and power to tell Mathematica exactly what you wanted to do
- **Rule 1**: Capital letters to start all function names
- **Rule 2**: Function arguments are enclosed by square brackets [ ]
- **Rule 3**: Lists, ranges, and domains are enclosed by curly braces { }
- **Rule 4**: To suppress output, use a semicolon , ';'
- (Task) Plot $y = 3x - 7$ from -3 to +3

In[•]:=
```
Plot[ 3 x - 7, {x, 0, 7}]
```

Out[•]=



- **To get help for built-in functions**: use any of the following methods
  - go to Menu bar (Help > Find Selected Functions)
  - type '? + name of function'
  - click the double chevron which appears, when you put mouse cursor, on the function name

In[]:= `? Plot`

Out[]=

Symbol

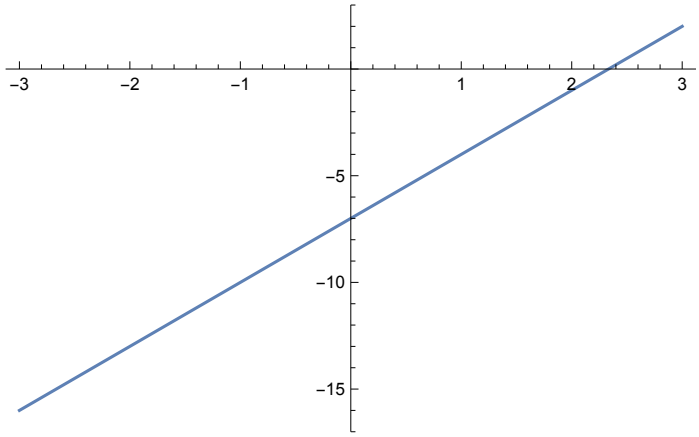
Plot[f, {x, x_{min}, x_{max}}] generates a plot of f as a function of x from x_{min} to x_{max}.
Plot[{f_1, f_2, …}, {x, x_{min}, x_{max}}] plots several functions f_i.
Plot[{…, w[f_i], …}, …] plots f_i with features defined by the symbolic wrapper w.
Plot[…, {x} ∈ reg] takes the variable x to be in the geometric region reg.

1.3 Palettes

- An alternate way to enter calculations
- (Task) Plot $y = 3x - 7$ from -3 to +3 (Palettes > Basic Math Assistant > Basic Commands > 2D > Plot)

In[]:=
```
Plot[3 x - 7, {x, -3, +3}]
```

Out[]=



2. Basic Calculations

2.1 Numerical Output

- Mathematica always gives you exact result where possible for numerical calculations
- If you want numerical approximation, use numerical approximation function N[ ] or the suggestion bar option, or enter numerical values with a dot
- (Task) calculate numeric approximation of $\frac{1}{\sqrt{2\pi}}$.
  - (To enter $\sqrt{\blacksquare}$, use Palettes > Basic Math Assistant > Typesetting (or Calculator) **OR** keyboard shortcut 'Ctrl + 2')
  - (To enter π, use Palettes > Basic Math Assistant > Typesetting (or Calculator) **OR** keyboard shortcut 'Esc + p +Esc')

In[•]:=
$$\frac{1}{\sqrt{2\,\pi}}$$

Out[•]=
$$\frac{1}{\sqrt{2\,\pi}}$$

In[•]:=
```
N[1/Sqrt[2 π], 3]
```

Out[•]=
```
0.399
```

In[•]:=
```
1.0/Sqrt[2 π]
```

Out[•]=
```
0.398942
```

2.2 Variable Assignments (use '=' sign)

- Mathematica can be used to evaluate expressions
- If a variable is not previously assigned a value, it is shown in blue color. Once a value is give for it, then Wolfram Language keeps it in memory and usually assumes that it is assigned **globally**. This means that every time you use the variable, the Wolfram Language assumes that you are referring to the same object.
- Use **Clear[ ]** function to clear the value assigned to a given variable from memory
- However, you may not want all your variables to be global. Sometimes, you may wish to name the letter *y* to refer to two different variables in two different programs. In this case you are required to use *y* in each program as a **local variable.** The **Module[ ]** function (see below) can be used in this case.
- (Task) evaluate *3a+1* for *a = 3*

In[•]:=
```
a = 2;
3 a + 1
```

Out[•]=
```
7
```

In[•]:=
```
Clear[a]
```

2.3 Substitution (use '/.' sign)

- (Task) Substitute a = 3 in *3a+1*

In[•]:=
```
3 a + 1 /. a → 2
```

Out[•]=
```
7
```

2.4 Integrate and Simplify

- (Task) Integrate cos (2x) and simplify the result

In[•]:=
```
Integrate[Cos[2 x], x]
```

Out[•]=
$$\frac{1}{2}\,\text{Sin}[2\,x]$$

```
In[•]:= Simplify[1/2 Sin[2 x]]
Out[•]= Cos[x] Sin[x]
```

2.5 Solving equations (use '==' sign)

- (Task) solve *3y+12 =0*

```
In[•]:= Solve[3 y + 12 == 0, y]
Out[•]= {{y → -4}}
```

2.6 Defining Functions (use 'f[var1_,var2_,...]:=')

- (Task) Suppose $f(x, y) = x^2 + y^2$. Find $f(2,2)$. (To enter superscript 2 use 'Control + 6' OR 'Insert > Typesettining)

```
In[•]:= f[x_, y_] := x^2 + y^2;
In[•]:= f[2, 2]
Out[•]= 8
In[•]:= Clear[f]
```

2.7 Create Own Function with Local variables (use Module [ ])

- (Task) Create a function to solve $x^2 = n$, for various integer values of n

```
In[•]:= myFunc[n_] := Module[{a}, a = n; Solve[x^2 == a, x]]
In[•]:= myFunc[3]
Out[•]= {{x → -√3}, {x → √3}}
```

- (Task) create a function to add n integers from 1 to n

```
In[•]:= myFunc[n_] := Module[{k}, Sum[k, {k, 1, n}]]
```

3. Basic Graphics

- (Task) plot sin(x) from -2π to 2π
  - change the domain from 0 to π
  - label the graph,
- (Task) plot sin($x^2 + y^2$) for x between -3 to 3, and y between -3 to 3
- (Task) create a 3D graph of *sin(x y)* , *x, y* between $-\pi$ to $+\pi$

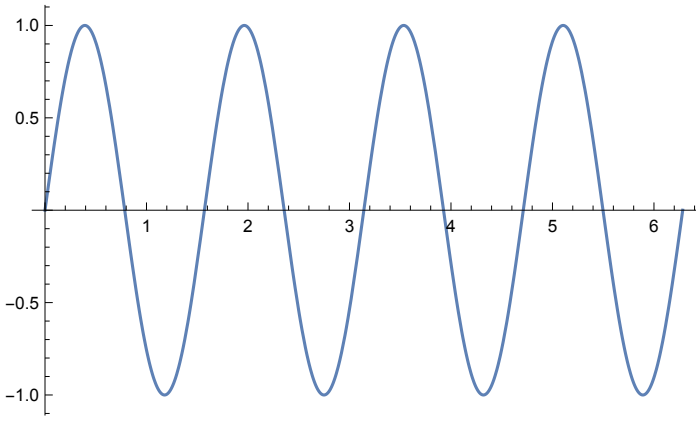
4. Interactive Models

- Interactive plots allow you to visualise changes to a plot when variables are varied
- To create an interactive model use Manipulate[ ] function

- (Task) Visualise *sin(frequency x)* as frequency varies from 1 to 5

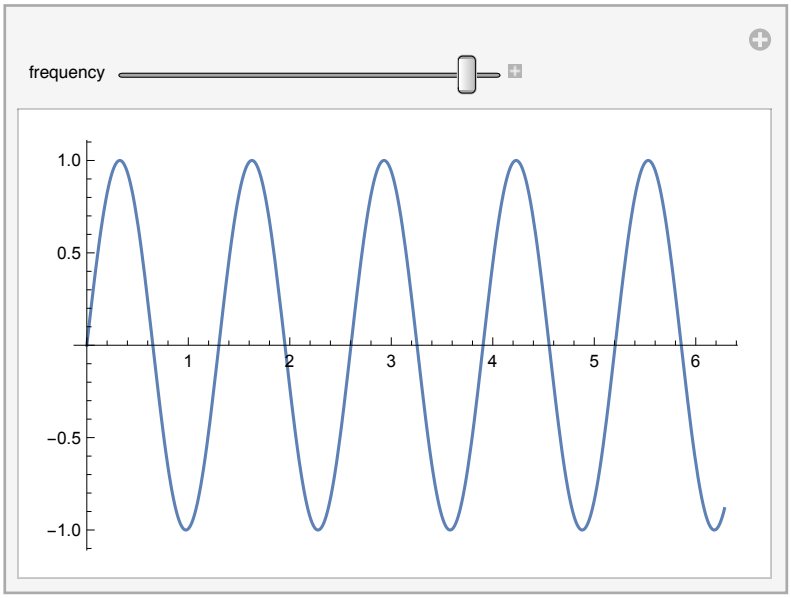
In[•]:=
```
Plot[Sin[4 x], {x, 0, 2 π}]
```

Out[•]=



In[•]:=
```
Manipulate[Plot[Sin[frequency * x], {x, 0, 2 π}], {frequency, 1, 5}]
```

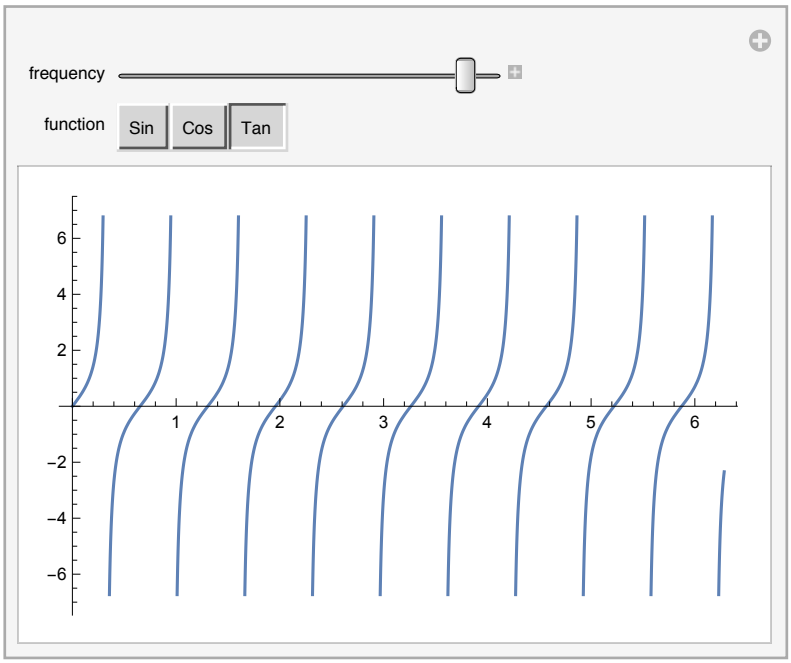
Out[•]=



- (Task) Visualise *sin(frequency x)*, *cos(frequency x)*, *tan(frequency x)* as as both *frequency* and trig functions varies

In[]:=
```
Manipulate[Plot[function[frequency * x], {x, 0, 2 π}],
 {frequency, 1, 5}, {function, {Sin, Cos, Tan}}]
```

Out[]=



- (Task) visualise expansion of $(y + z)^n$ for n from 1 to 100 in steps 1

5. Matrices

5.1 Three Methods to Create a Matrix

By Typing (crate a list of lists list {{a, b, c}, {d, e, f}} and MatrixForm)

- (Task) Create a matrix with 2 rows and 3 columns

In[]:=
```
A = {{a, b}, {c, d}}
```

Out[]=
```
{{a, b}, {c, d}}
```

In[]:=
```
A // MatrixForm
```

Out[]//MatrixForm=

$$\begin{pmatrix} a & b \\ c & d \end{pmatrix}$$

Using Keyboard Shortcuts

- Use ‘Ctrl + ,’ to add a column
- Use ‘Ctrl + Enter’ to add a row

$$\begin{pmatrix} a & b \\ c & d \end{pmatrix}$$

Using Table [ ] Function

- From Menu bar select Insert > Table/Matrix > New

$$\begin{pmatrix} a & b \\ c & d \end{pmatrix}$$

5.2 Determinant (Use Det [ ] Function)

- (Task) Compute general formula for determinant of a 2 by 2 matrix

```
In[]:= Det[A]
```

$$\text{Out[]}= -b\,c + a\,d$$

5.3 Inverse (Use Inverse[ ] Function)

- (Task) Compute general formula for inverse of a 2 by 2 matrix

```
In[]:= Inverse[A]
```

$$\text{Out[]}= \left\{\left\{\frac{d}{-b\,c + a\,d}, -\frac{b}{-b\,c + a\,d}\right\}, \left\{-\frac{c}{-b\,c + a\,d}, \frac{a}{-b\,c + a\,d}\right\}\right\}$$

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6. Classic Programming

- (Task) Use Do[ ], For[ ], and While[ ] loops to print the first four square numbers

6.1 Do[ ] Loop

```
In[]:= Do[Print[n^2], {n, 1, 4}]
1
4
9
16
```

6.1 For[ ] Loop

```
In[]:= For[n = 1, n < 5, n++, Print[n^2]]
1
4
9
16
```

6.1 While[ ] Loop

```
In[]:= n = 1;
While[n < 5, Print[n^2]; n++]
```

```
1
4
9
16
```

7. More Resources

- Help > Wolfram Documentation (or https://reference.wolfram.com/language/)
- **Mathematica based exercises,** link provided in MATH7501 course website
- Dr Sam Hambleton YouTube tutorials, link provided in MATH7501 course website