ENGG1811 Computing for Engineers

Spreadsheet
Spreadsheet

• A popular application used at home as well as in the office
• Many applications: Data analysis, finance, management
• We will first learn how to use it
  – We will later compare it against Python

• Topics to be covered
  – Spreadsheet basics
    • Structure, formula, addressing
  – Conditional and Boolean
  – Programming in Excel (Demonstration only, not in exam)
Some terminology

- A spreadsheet file is also known as a workbook
- A workbook contains one or more worksheet
  - The following picture shows a blank worksheets
Each sheet is divided into rows and columns.

Rows are labelled as integers starting from 1 (up to 1 million+); column labels are from A to Z, AA to AZ, BA to BZ, etc. (up to 1000+).

The intersection of a row and column forms a cell. Each cell has a unique cell reference. For example, the cell at the intersection of column D and row 10 is called D10.
Adding rows and entering data

• Our first exercise is to add a row of data
• It should look like the following after it’s done

Worksheet: sturec_1

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><strong>Student</strong></td>
<td><strong>Test1</strong></td>
<td><strong>Test2</strong></td>
<td><strong>Final</strong></td>
</tr>
<tr>
<td>2</td>
<td>Susie</td>
<td>100</td>
<td>85</td>
<td>81</td>
</tr>
<tr>
<td>3</td>
<td>John</td>
<td>75</td>
<td>87</td>
<td>92</td>
</tr>
<tr>
<td>4</td>
<td>Mary</td>
<td>85</td>
<td>92</td>
<td>77</td>
</tr>
<tr>
<td>5</td>
<td>Paul</td>
<td>94</td>
<td>62</td>
<td>76</td>
</tr>
<tr>
<td>6</td>
<td>Kate</td>
<td>64</td>
<td>98</td>
<td>83</td>
</tr>
</tbody>
</table>

Add this row
Every cell in a spreadsheet contains either a **constant** or a **formula**

A **constant** is an entry that the spreadsheet does not change, for example, test marks, student name or a date.

A **formula** is a combination of numeric constants, cell references, arithmetic operators, and functions that returns the result of a calculation. Formulas are prefixed by an equal sign (=).
A **function** performs a predefined computational task.

For example, the function **AVERAGE(B2:B6)**, in cell B8, calculates the average of all the cells in the **range** from B2 to B6 inclusive.

Excel provides many useful functions for mathematical, statistical, financial and other tasks. We will come back to this topic later.
Copy and Paste Commands

The **copy** command duplicates the contents of a cell, or range of cells.

The **paste** command copies the contents to the destination cell, or range of cells. However, a formula is *not copied exactly*, but is adjusted as it is copied, depending on the destination cell.

For example, if the formula in cell **B8** is copied to cell **C8**, it is adjusted so that the cells referenced in the new formula are in the same **relative position** as those in the original formula.

Worksheet: sturec_1

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Student</td>
<td>Test1</td>
<td>Test2</td>
<td>Final</td>
<td>Average</td>
</tr>
<tr>
<td>3</td>
<td>Susie</td>
<td>100</td>
<td>85</td>
<td>81</td>
<td>88.7</td>
</tr>
<tr>
<td>4</td>
<td>John</td>
<td>75</td>
<td>87</td>
<td>92</td>
<td>84.7</td>
</tr>
<tr>
<td>5</td>
<td>Mary</td>
<td>85</td>
<td>92</td>
<td>77</td>
<td>84.7</td>
</tr>
<tr>
<td>6</td>
<td>Paul</td>
<td>94</td>
<td>62</td>
<td>76</td>
<td>77.3</td>
</tr>
<tr>
<td>7</td>
<td>Kate</td>
<td>64</td>
<td>98</td>
<td>83</td>
<td>81.7</td>
</tr>
<tr>
<td>8</td>
<td>Class Average</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

original formula is \=AVERAGE(B2:B6)
copied formula is \=AVERAGE(C2:C6)

Same principle applies to:
- inserting rows and columns
- deleting rows and columns
- filling operations
### Relative addressing demo

- Original formula in A7 is B2 + D3
  - Note these cells have background colour
- The formula in A7 is copied to A8, which becomes B3 + D4
  - Background colour
- The formula in A7 is copied to C7, which becomes D2 + F3
  - Background colour

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>2</td>
<td></td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>2</td>
<td>7</td>
<td>8</td>
<td></td>
<td>9</td>
<td>10</td>
<td>11</td>
<td>12</td>
</tr>
<tr>
<td>3</td>
<td>13</td>
<td>14</td>
<td></td>
<td>15</td>
<td>16</td>
<td>17</td>
<td>18</td>
</tr>
<tr>
<td>4</td>
<td>19</td>
<td>20</td>
<td>21</td>
<td>22</td>
<td>23</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>24</td>
<td></td>
<td></td>
<td>28</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
<td>36</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Filling combined copy and paste over a range of cells

Step 1: select range, usually in one direction, down or right

Step 2: pick the Edit – Fill menu item to fill down (if vertical) or right (if horizontal)

**Auto-fill shortcut:**

Step 1: select initial cell (the one with the original formula, B8)

Step 2: grab the auto-fill handle (square dot at bottom right)

Step 3: cursor changes to +, drag the range, fill is completed on release

Extra-special deal: select two adjacent cells containing numbers, auto-fill completes an arithmetic progression with tooltip feedback
Absolute vs Relative References

In a formula, if the cell reference has $ signs in front of the row and column designation, it is considered an **absolute reference** and the cell reference remains **unchanged** throughout all copy/paste operations, e.g., $B$10

A **relative reference**, on the other hand, adjusts during copy operations and is specified without $ signs, e.g., B2

A **mixed reference** uses a single $ sign to make the column or the row absolute, leaving the other as relative. For example F$6 or $F6
Formatting Cells

The appearance of a cell can be changed by altering fonts, borders, colour fill and number formatting, including indents.

Note that changing the format of a number affects the way the number is displayed but does not change its value.

Formats can be changed from the toolbar.
Right-click on the cell and choose Format Cells.
Named Cells

A special form of absolute reference is to give a cell a *name*, using letters only.

Select a cell (or a *range*) and enter the intended name in the *name box*, or pick *Insert – Names – Define* from the menu (lists all existing names).

Names can be used in formulas – think about variable names in Python and Matlab.
Charts

The graphical representation of data can be an attractive, easy-to-understand way to convey information.

Any good spreadsheet application will let you create charts from the spreadsheet data, with just a few simple keystrokes or mouse clicks.
Creating Charts and Plots

You can produce different types of charts with Excel, including column and bar charts, and line and scatter plots (more applicable to engineering data)

Procedure: select the source data range, (usually including headers), then click on the Insert tab, and choose from the options

To change the axis label, select it, right click and choose from the options
Useful Functions and Features

• Excel provides many **predefined functions** and **features** that could prove very useful in solving many real life problems.

• Excel offers a wide range of Mathematical functions. For example:
  
  – Elementary Math[s] Functions
  – Trigonometry functions
  – Advanced Math Functions
  – Financial functions
  – *etc, etc*

• You can find more information on all of these from **Microsoft Excel Help**
Documentation

- Excel provides a lot of useful functions
- You can search or browse the documentation
  - Go to the top menu, look under Help
  - We will browse through a few categories

Excel functions (by category)

Worksheet functions are categorized by their functionality. Click a category to browse its functions. Or press Ctrl+F to find a function by typing the first few letters or a descriptive word. To get detailed information about a function, click its name in the first column.

<table>
<thead>
<tr>
<th>Category</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Our 10 most popular functions</td>
<td></td>
</tr>
<tr>
<td>Compatibility functions</td>
<td></td>
</tr>
<tr>
<td>Cube functions</td>
<td></td>
</tr>
<tr>
<td>Database functions</td>
<td></td>
</tr>
<tr>
<td>Date and time functions</td>
<td></td>
</tr>
<tr>
<td>Engineering functions</td>
<td></td>
</tr>
</tbody>
</table>
Example

• We will work on an example on computing the trajectory of a projectile
• In this example, we will use the following knowledge that you have learnt:
  – Constants
  – Formulas
  – Addressing
  – Names
  – Functions (Trigonometric functions in this example)
  – Fill
  – Charting
Organising Data – Sorting

- Data values can be sorted in ascending or descending order, using numeric or text comparisons as appropriate
- **Procedure:**
  - Select range *must include all associated values*: select complete rows
  - Pick Data – Sort
  - Can have multiple criteria, ascending or descending
  - Formulas are adjusted

![Spreadsheet Image](image-url)
Filtering in Excel:

- Filtering is a quick and easy way to find and work with a subset of data in a list. A filtered list displays only the rows that meet the criteria you specify for a column.  
  (from MS Excel Help)

Two commands for filtering lists:

- **AutoFilter**, which includes filter by selection, for simple criteria
- **Advanced Filter**, for more complex criteria
Filtering, continued:

- Filtering does not rearrange a list. Filtering temporarily hides rows you do not want displayed.

- .... Live Demonstration .......

- You can find more information on all of these from Microsoft Excel Help, and also from online tutorials on Excel (available on the class web page)
More useful Functions

Common Functions:

- **SUM**
  - Example: $\text{SUM}(C2:C8)$ equals 94

- **AVERAGE**
  - Example: $\text{AVERAGE}(C2:C8)$ equals 13.428571

- **COUNT**: Counts the number of cells that contain numbers
  - Example: $\text{COUNT}(B2:B8)$ equals 4

- **COUNTA**: Counts the number of cells that are not empty
  - Example: $\text{COUNTA}(B2:B8)$ equals 6
More useful functions

- **COUNTIF**: Counts the number of cells within a range that meet the given criteria
  - Example: `COUNTIF(C2:C8, "<10")` equals 2

- **SUMIF**: Adds the cells specified by a given criteria.
  - Example: `SUMIF(B2:B8,"Absent", C2:C8)` equals 29

Worksheet: sturec_2

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Name</td>
<td>Labs Total</td>
<td>Assignments</td>
</tr>
<tr>
<td>2</td>
<td>Linda</td>
<td>75</td>
<td>19</td>
</tr>
<tr>
<td>3</td>
<td>Sue</td>
<td>Absent</td>
<td>17</td>
</tr>
<tr>
<td>4</td>
<td>Paul</td>
<td>40</td>
<td>8</td>
</tr>
<tr>
<td>5</td>
<td>Rob</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>John</td>
<td>66</td>
<td>15</td>
</tr>
<tr>
<td>7</td>
<td>Jesse</td>
<td>Absent</td>
<td>12</td>
</tr>
<tr>
<td>8</td>
<td>Rita</td>
<td>78</td>
<td>18</td>
</tr>
</tbody>
</table>
**Conditional Functions**

- **IF**: Returns one value if a condition you specify evaluates to TRUE and another value if it evaluates to FALSE.

  \[
  \text{IF}(\text{logical\_test}, \text{value\_if\_true}, \text{value\_if\_false})
  \]

  Examples:

  \[
  \text{IF}(F5 \geq 85, "HD", "Below HD")
  \]

  \[
  \text{IF}(C5 < 50, "FL", \text{IF}(C5 \geq 85, "HD", "Between PS and DN"))
  \]

  *C5<50?*  
  - true (less than 50)
  - false (at least 50)

  *C5≥85?*  
  - true (at least 50 and at least 85)
  - false (at least 50 but less than 85)

  Strings are enclosed by double quotes
Logical (Boolean) Functions

Logical Functions combine conditions:

- **AND**: Returns TRUE if all its arguments are TRUE; returns FALSE if one or more arguments is FALSE. Example:

  \[
  \text{IF(AND(B2>75, C2>15), "Very Good", "Room for improvement")}
  \]

- **OR**: Returns TRUE if any argument is TRUE; returns FALSE if all arguments are FALSE. Example:

  \[
  \text{IF(OR(B2>75, C2>15), "Good", "Must try harder")}
  \]

- **NOT**: Reverses the value of its argument, a logical expression. Example:

  \[
  \text{IF(NOT(C5<50), "PS", "FL")}
  \]

AND and OR can accept multiple Boolean expressions.
• Consider the worksheet If_Quiz, shown below
• Column A contains some data
• Cell B1 contains the formula: \( =IF(A1>=50,1,0) \)
  – And this formula is copied to cells B2 to B5
• Cell C1 contains the formula: \( =IF(A1>=50,"1","0") \)
  – And this formula is copied to cells C2 to C5
• Without actually entering the formulas, can you predict what the output is if you enter the formula:

=IF(B1=C1,"Yes","No") in Cell E1

=SUM(B1:B5) in Cell B7

=SUM(C1:C5) in Cell C7

• Now enter the formulas and see whether your prediction is right?
• What have you learnt?
Counting heart beat automatically

• Pulse oximetry sensor

• We will use spreadsheet to count heart beat almost automatically

http://pulsesensor.com
Counting number of heart beats

# heart beats = # tall peaks
Peak or not

Can you come out with a logical condition that distinguish a peak from a non-peak?

Peak = value at the point is greater than its two neighbours’
Tall or not tall?

We can set a threshold and require the value at the peak must be greater than or equal to this threshold.

We will use a threshold of 3.
Counting number of heart beats

- You know how to determine whether a point is a peak or not

- However, not all the peaks are tall peaks

- We only want to count those peaks whose voltage exceeds a threshold
  - This means we need an additional logical condition

- You have done that in Python. How will you do this in Excel?
  - This is an exercise for you to work in the lecture
Exercise: Counting number of heart beats

• You can choose the method that you want
• One possibility is:
  – In Column C, determine whether a point is a peak
  – In Column D, determine whether the point exceeds the threshold
    • Note: The cell H1 has been named \textit{threshold} and you can use that name
  – Combine the results of Columns C and D, and then get Excel to count for you
• You are free to use other methods
Visual Basic for Applications (VBA)

- Visual Basic for Applications (VBA) is a programming language that comes with Excel
  - It’s also available for other Microsoft Office products
- The process of counting the heart beats involves some manual processes, e.g. filling down the columns
- VBA allows users to automate the work
- We will show you the code and run it
  - From the top menu, follow this sequence: Tools, Macros, Visual Basic Editor

Note: For ENGG1811, we do not expect you to code in VBA but would like to show you the possibility
### Comparing Excel and Python

<table>
<thead>
<tr>
<th>Features in Excel</th>
<th>Concepts in Python</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spreadsheet</td>
<td>2 Dimensional List (List of Lists)</td>
</tr>
<tr>
<td>Cell</td>
<td>Element in list</td>
</tr>
<tr>
<td>Filling a cell</td>
<td>Assignment to variable</td>
</tr>
<tr>
<td>Default cell name</td>
<td>Indexing</td>
</tr>
<tr>
<td>Naming a cell</td>
<td>Variable name</td>
</tr>
<tr>
<td>Copy formula and fill</td>
<td>Loops (For or While)</td>
</tr>
<tr>
<td>Visual presentation of data</td>
<td>No built-in visualisation</td>
</tr>
<tr>
<td>Automatic propagation</td>
<td>Re-run code</td>
</tr>
<tr>
<td>Can only deal with a limited amount of data</td>
<td>Can deal with big amounts of data</td>
</tr>
</tbody>
</table>
Summary

- Spreadsheet as an application created by programming
- Key concepts of spreadsheet
  - Copy and paste formulas; filling;
  - Naming cells
  - Addressing
  - Data analysis: sorting, filtering
  - Conditional