

EXCEL HINTS

for

SCIENCE AND ENGINEERING MAJORS

Ch. 1 - Ch. 3

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Preface

The purpose of this booklet is to provide an introduction to Microsoft **Excel**. This text was originally written for Excel 2013. There have been some cosmetic and feature updates to Excel, but the basics remain the same.

After many years with the same interface (e.g., **Excel 2003**, *Fig. 1a*), Microsoft changed the appearance of its Office Suite (e.g., **Excel 2007**, *Fig. 1b*). The traditional **Menus** at the top of the program window were replaced by a **Microsoft Office Button** and **Ribbon** interface. With Excel 2010, the button was replaced with the File tab.

The intent of this course (ENGR 124) is to provide you with what I call **guided exploration** of Excel. You will be provided with information, tools and hints to use Excel. Then, you will use Excel to perform various tasks that might be found in the fields of science and engineering. These exercises (problems) primarily use Excel to perform calculations and analyze data, and to create plots. You may learn (relearn) some mathematics along the way.

In terms of mathematics, I am assuming that you have completed Calculus 1 (derivatives). Numerical differentiation and integration are the last topics of this course. Some mathematical concepts are explained in more detail (e.g., logarithmic scales), than those you should be familiar with (e.g., the quadratic formula).

The science and engineering principles behind the mathematics used in this course are either briefly explained in class or on the assignment sheets, or are secondary to the exercise (i.e., simply take the data as given and plot it); you will be given (non-trivial) equations; and then need to implement them in Excel.

Generally, for each exercise you will have some goal/objective to meet (e.g., solve an equation, create a plot). I usually do not give step-by-step instructions on how to use Excel to do a particular exercise, as part of the process is **problem solving** and **exploring**. However, do not bang your head against the wall for too long; do not be afraid to ask for help (hints) from the instructor.

Do not be afraid to use **Help** located at the upper right of the Excel Window – or its keyboard shortcut **[F1]** – to look up a command or function, etc. Other used references are this brief booklet (e.g., formulas and functions in Chapter 3), books on Excel, and the many internet resources.

I have grouped the exercises/assignments into “modules.” Each module has one, two or three topics. Typically, students are able to complete the modules well within the semester. However, one must consistently work at it each week – at least 1.5 to 2 (focused) hours per week. Do not put the work off.

CAUTION! **Your goal is to become more familiar with Excel.** If all you are doing is trying to complete the modules as fast as possible to satisfy the requirements of the course, you are probably not retaining much. You should be able to use (at least know where to start) the concepts of each module after the course is over. **Learn.**

Finally, this booklet/course is not meant to be a complete manual/survey of Excel. There are many Excel features that are beyond the scope of this course. I recommend that you explore these features. Becoming an expert in Excel will serve you well in the future.

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Fall 2020

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1.0 Introduction

Excel is a spreadsheet program originally developed for business applications. Before computers, accountants used large paper spreadsheets to analyze financial information. When a number early in the spreadsheet would change, then the rest of the spreadsheet would need to be recalculated by hand. Computer applications such as Excel allowed those many calculations to be automated, reducing time and the potential for error.

But Excel is also very useful in science and engineering fields. Among other uses, Excel:

- is a powerful calculation tool,
- can create publication-ready graphs, and
- can be used as a database.

When you open Excel, the entire program window is called the **Workspace** (Figs. 1 and 2).

Figs. 1a and 1b show the workspace for **Excel 2003** and **Excel 2007** respectfully, and Figs. 2a, 2b and 2c show the workspace for **Excel 2010**, **2013**, and **Excel 365** (the subscription version of **Excel 2019**). Details have changed, but the overall look has remained fairly constant.

Excel's spreadsheet area – called a **worksheet** – is divided into **columns** (lettered) and **rows** (numbered), similar to an accountant's ledger or a data table. Each **cell** is identified by its lettered column (**A**, **B**, etc.) and its numbered row (**1**, **2**, etc.). The **address** of a cell is given by its column and row; e.g., the **active cell** (selected cell) in Figs. 1 and 2 is **B5**.

The default worksheet names are Sheet1, Sheet2 and Sheet3, etc. A worksheet can be renamed to something more identifiable by **RIGHT-CLICKING** on the sheet's tab at the bottom of the worksheet, and selecting Rename.

An Excel file – called a **workbook** – consists of one or more worksheets. The default workbook name is Book1. The extensions are .xls (Excel 2003) and .xlsx (Excel 2007, 2010, 2013, 2016, 2019 ~ Excel 365).

In Excel 2003, a **worksheet** could have up to 255 columns and 65,536 rows; there could be up to 255 worksheets in a single workbook. That's over 16 million cells in a worksheet, and over 4 billion cells in the workbook! Since **Excel 2007** through **Excel 2013**, there can be 16,384 columns and 1,048,576 rows – over 17 billion cells – in a single worksheet. The number of worksheets in a workbook is limited only by the computer's memory (or your ability to keep everything organized in your mind).

The worksheet may be navigated with the mouse cursor/pointer (by clicking on cells, or by click-and-dragging to select several cells), or with the Arrow Keys on the keyboard.

1.1 Navigation Nomenclature

In class, or in this booklet, you may hear/read the following phrases shown in CAPITAL letters. These phrases indicate how to navigate in Excel.

CLICK (LEFT CLICK)

point with the mouse to a cell (or object), and click the left mouse-button (if a Mac, there is only one mouse button). This action will select the cell or the object.

DOUBLE-CLICK

point with the mouse to the indicated object and click twice, quickly.

RIGHT-CLICK

pressing the right button on the mouse in Windows will bring up a shortcut menu with common commands based on the currently selected object.

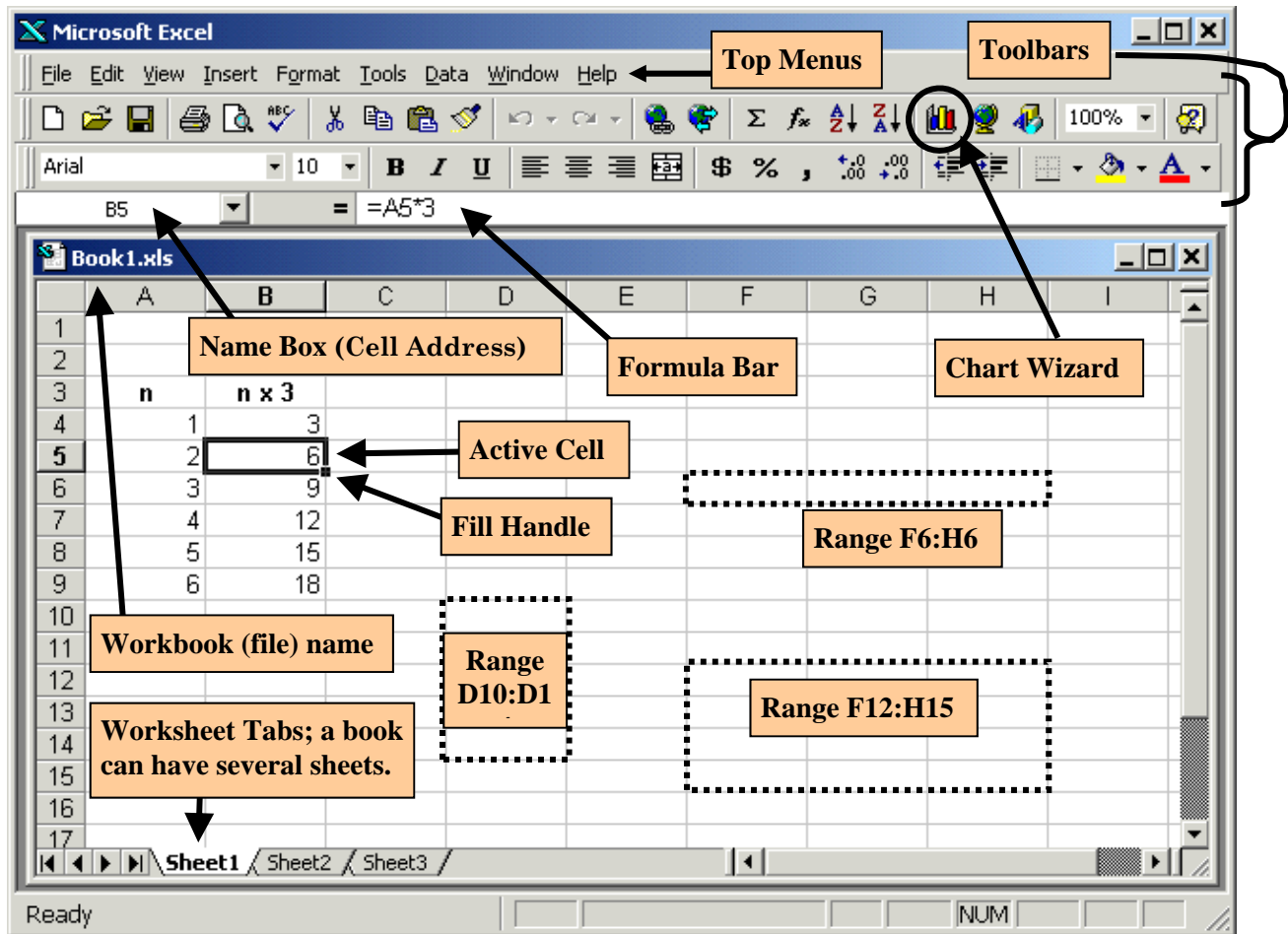


Fig. 1a. A typical **Excel 2003 Workspace**. The default **Workbook** (file) name is Book1.xls. Each **Workbook** contains several **Worksheets** (spreadsheets).

The **Active Cell (Selected Cell)** is **B5**. The **address** or **name** of the active cell is displayed to the left of the **Formula Bar**. The active cell has a thick border, with a **Fill Handle** at its lower right; the Column (B) and Row (5) Titles (Headings) are highlighted.

The **Formula Bar** displays the contents of the active cell, which in this case is a formula:

= A5*3 ... meaning take the value in **A5** and multiply it by **3**.

A **Range** is a set of cells that are grouped together. The **cells D10, D11, D12, D13, D14** can be written as a range, **D10:D14**; this short-hand notation to indicate a group of cells is very useful.

The **Toolbars** (the palettes of graphical menu items just below the **Top Menu**) can be *customized*. You may customize your toolbars to include the menu commands that you most often use. To do so: **SELECT MENU Tools/Customize/Commands** and drag the appropriate command button onto a toolbar.

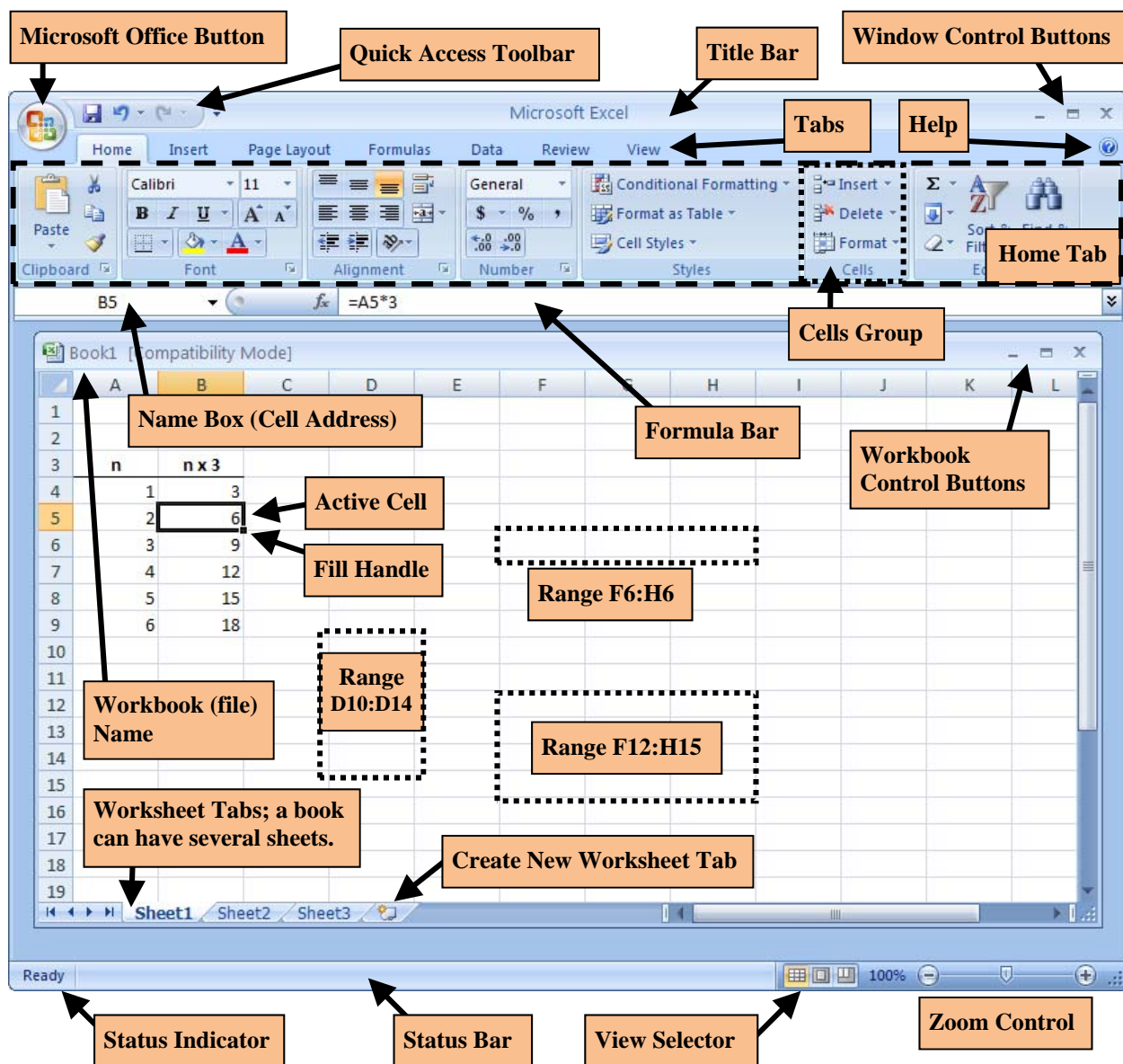


Fig. 1b. A typical Excel 2007 Worksheet. The default **Workbook** (file) name is Book1.xlsx. Each Workbook contains several **Worksheets** (spreadsheets).

The **Active Cell** (**Selected Cell**) is B5. The **address** or **name** of the active cell is displayed to the left of the **Formula Bar**. The active cell has a thick border, with a **Fill Handle** at its lower right; the Column (B) and Row (5) Titles (Headings) are highlighted.

The **Formula Bar** displays the contents of the active cell, which in this case is a formula: **= A5*3** ... meaning take the value in **A5** and multiply it by **3**.

A **Range** is a set of cells that are grouped together. The **cells D10, D11, D12, D13, D14** can be written as a range, **D10:D14**; this short-hand notation to indicate a group of cells is very useful.

The **Quick Access Toolbar** can be customized to display Excel commands and features that you commonly use. The default commands are *Save*, *Undo* and *Redo*.

The **Ribbon** has seven default **Tabs** that group like tools together. The **Home Tab** includes the following **Groups**: *Clipboard* (Cut/Copy/Paste tools), *Font*, *Alignment*, *Number* (Formatting), (Table) *Styles*, *Cell* (Properties) and *Editing* tools. The Ribbon can be minimized to show only the Tab titles (one of the selections in the drop down menu at the right of the *Quick Access Toolbar*). Other Tabs may appear as appropriate, e.g., a *Drawing Tools/Format Tab* appears when working with graphics.

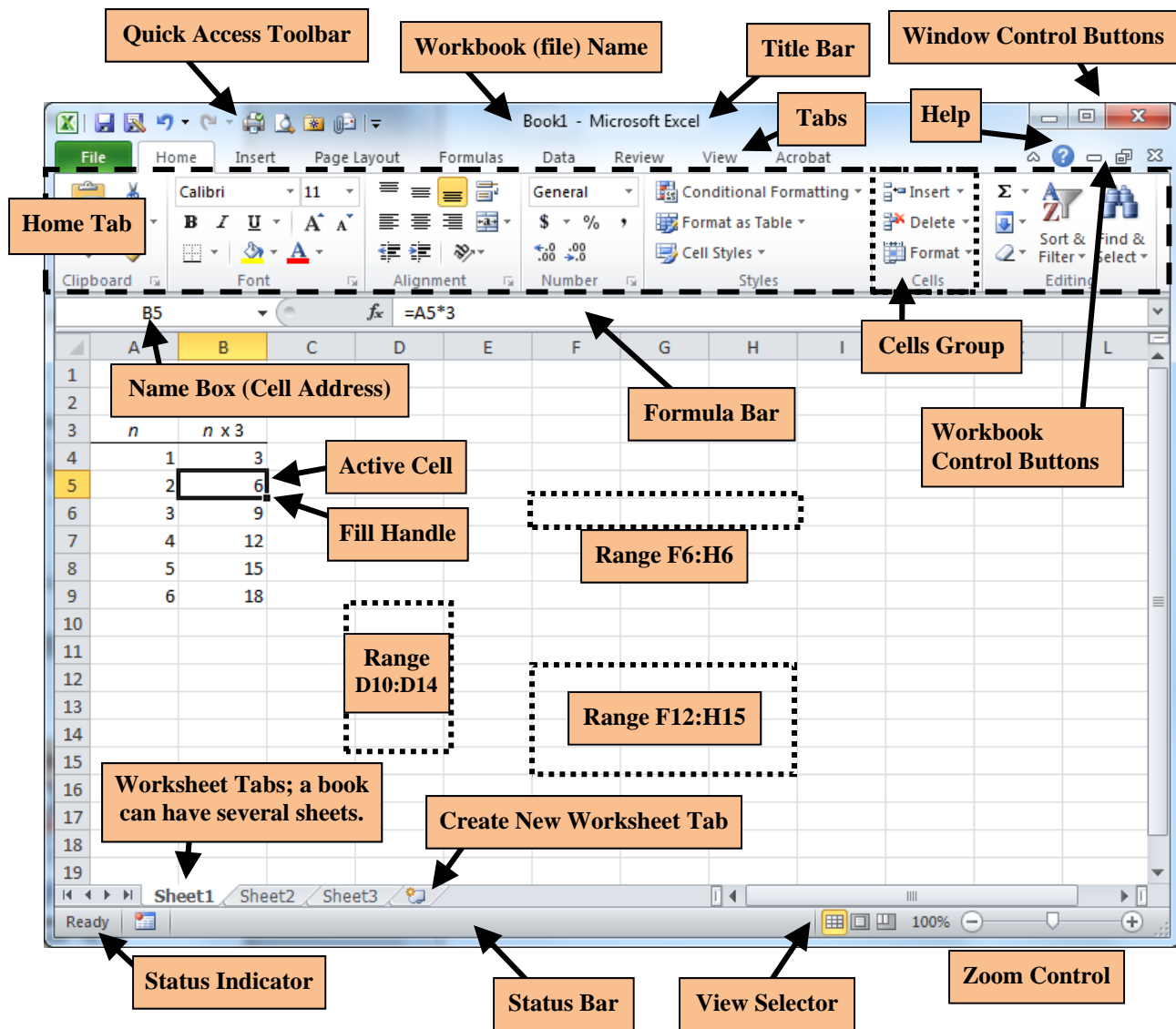


Fig. 2a. A typical **Excel 2010 Worksheet**. The default **Workbook** (file) name is Book1.xlsx. Each **Workbook** contains several **Worksheets** (spreadsheets).

The **Active Cell** (**Selected Cell**) is **B5**. The **address** or **name** of the active cell is displayed to the left of the **Formula Bar**. The active cell has a thick border, with a **Fill Handle** at its lower right; the Column (B) and Row (5) Titles (Headings) are highlighted.

The **Formula Bar** displays the contents of the active cell, which in this case is a formula: **= A5*3** ... meaning take the value in **A5** and multiply it by **3**.

A **Range** is a set of cells that are grouped together. The cells **D10**, **D11**, **D12**, **D13**, **D14** can be written as a range, **D10:D14**; this short-hand notation to indicate a group of cells is very useful.

The **Quick Access Toolbar** can be customized to display Excel commands and features that you commonly use. The default commands are *Save*, *Undo* and *Redo*.

The **Ribbon** has seven default **Tabs** that group like tools together. The **Home Tab** includes the following **Groups**: *Clipboard* (Cut/Copy/Paste tools), *Font*, *Alignment*, *Number* (Formatting), (Table) *Styles*, *Cell* (Properties) and *Editing* tools. The Ribbon can be minimized to show only the Tab titles (one of the selections in the drop down menu at the right of the **Quick Access Toolbar**). Other Tabs may appear as appropriate, e.g., a *Drawing Tools/Format Tab* appears when working with graphics. The *File Tab* replaced the Microsoft Office Button from Excel 2007.

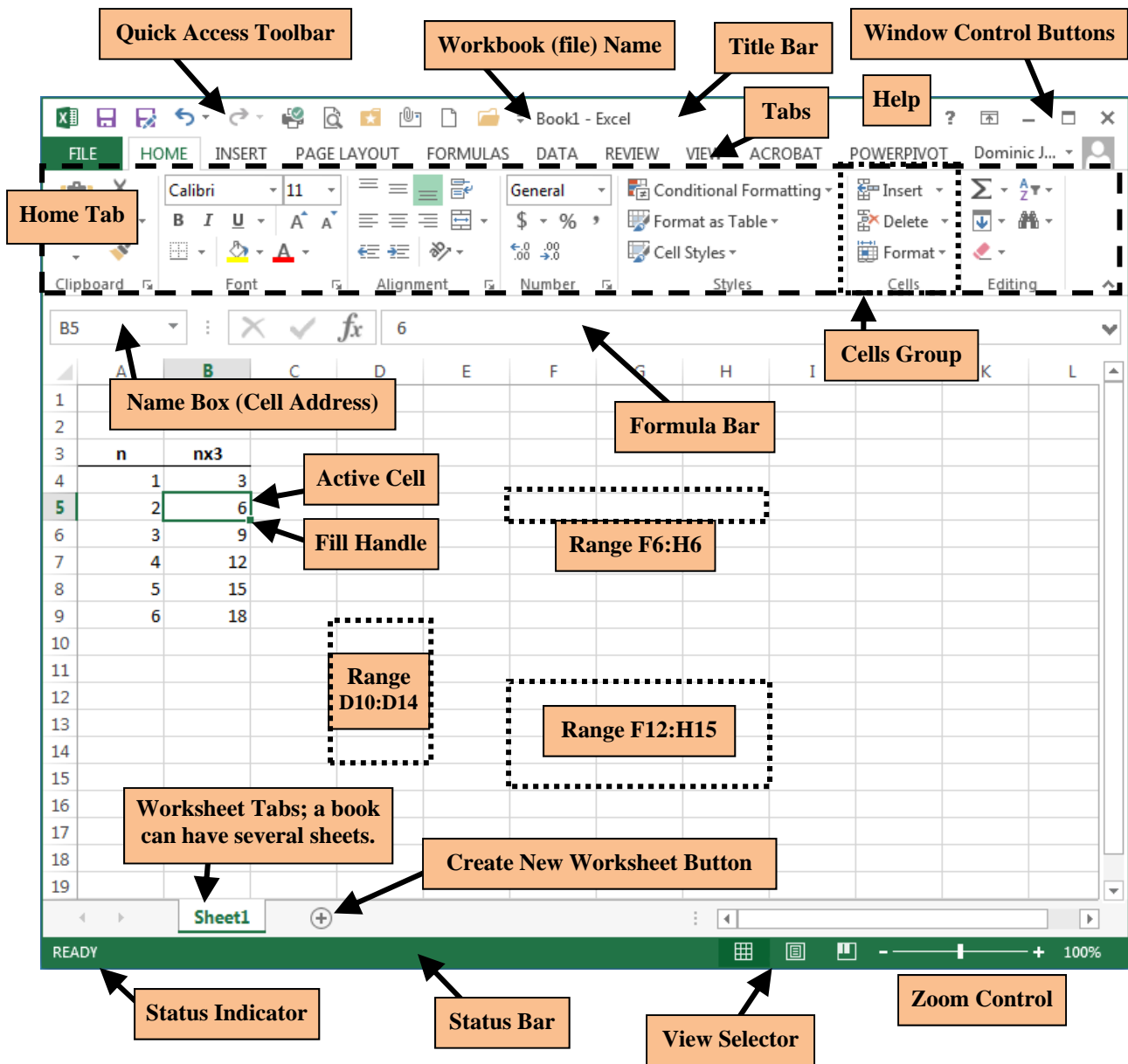


Fig. 2b. A typical **Excel 2013 Worksheet**. The default **Workbook** (file) name is Book1.xlsx. Each **Workbook** can contain several **Worksheets** (spreadsheets).

The **Active Cell** (**Selected Cell**) is B5. The **address** or **name** of the active cell is displayed to the left of the **Formula Bar**. The active cell has a thick border, with a **Fill Handle** at its lower right; the Column (B) and Row (5) Titles (Headings) are highlighted.

The **Formula Bar** displays the contents of the active cell, which in this case is a formula: `= A5*3` ... meaning take the value in **A5** and multiply it by **3**.

A **Range** is a set of cells that are grouped together. The **cells D10, D11, D12, D13, D14** can be written as a range, **D10:D14**; this short-hand notation to indicate a group of cells is very useful.

The **Quick Access Toolbar** can be customized to display Excel commands and features that you commonly use. The default commands are *Save*, *Undo* and *Redo*.

The **Ribbon** has seven default **Tabs** that group like tools together. The **Home Tab** includes the following **Groups**: *Clipboard* (Cut/Copy/Paste tools), *Font*, *Alignment*, *Number* (Formatting), *Styles*, *Cell* (Properties) and *Editing* tools. The Ribbon can be minimized to show only the Tab titles (one of the selections in the drop down menu at the right of the **Quick Access Toolbar**). Other Tabs may appear as appropriate, e.g., a *Drawing Tools/Format Tab* appears when working with graphics.

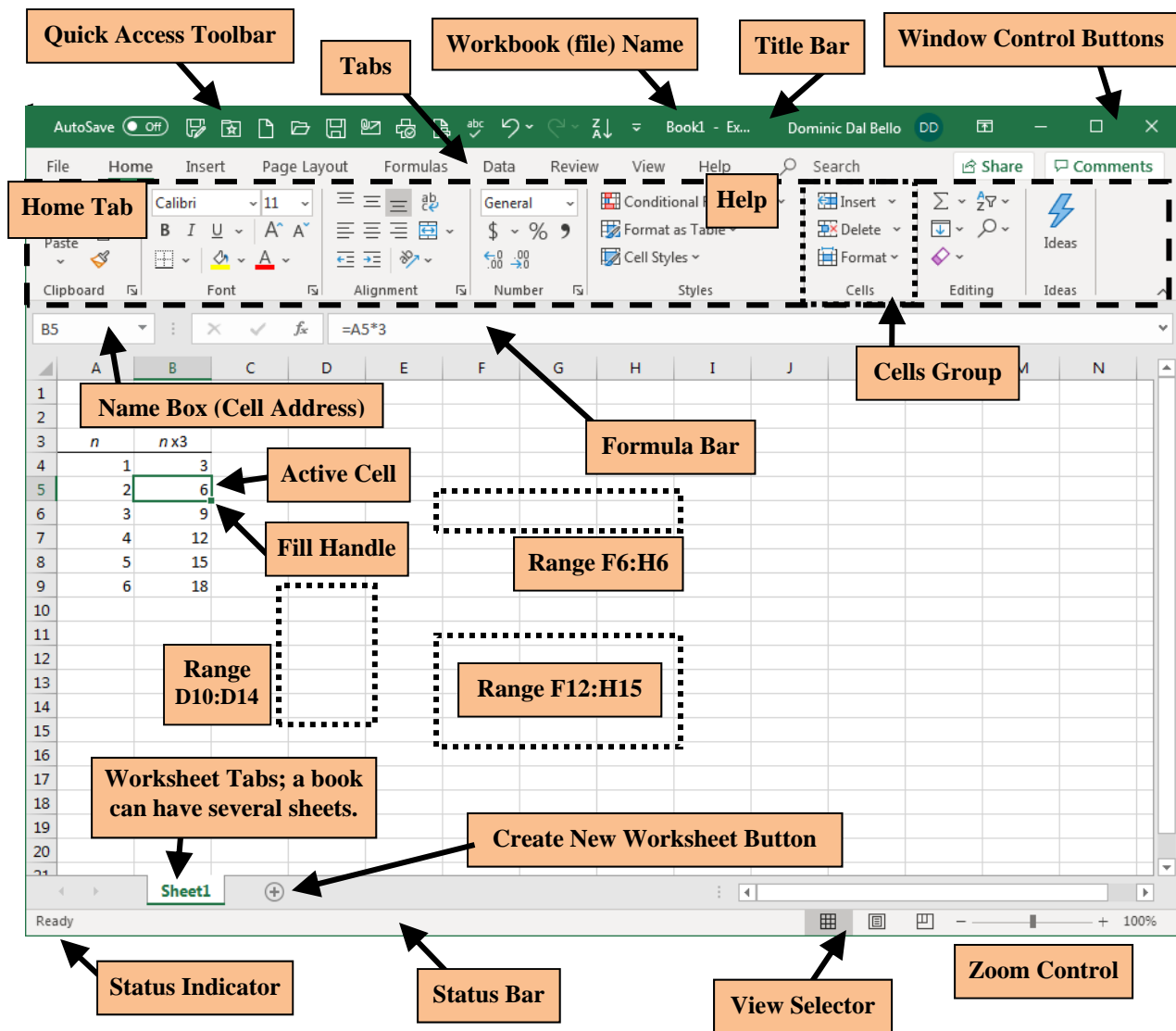


Fig. 2c. A typical **Excel 365 (Excel 2019) Worksheet**. The default **Workbook** (file) name is Book1.xlsx. Each **Workbook** can contain several **Worksheets** (spreadsheets).

The **Active Cell (Selected Cell)** is **B5**. The **address** or **name** of the active cell is displayed to the left of the **Formula Bar**. The active cell has a thick border, with a **Fill Handle** at its lower right; the Column (B) and Row (5) Titles (Headings) are highlighted.

The **Formula Bar** displays the contents of the active cell, which in this case is a formula: **= A5*3** ... meaning take the value in **A5** and multiply it by **3**.

A **Range** is a set of cells that are grouped together. The **cells D10, D11, D12, D13, D14** can be written as a range, **D10:D14**; this short-hand notation to indicate a group of cells is very useful.

The **Quick Access Toolbar** can be customized to display Excel commands and features that you commonly use. The default commands are **Save, Undo** and **Redo**.

The **Ribbon** has seven default **Tabs** that group like tools together. The **Home Tab** includes the following **Groups**: **Clipboard** (Cut/Copy/Paste tools), **Font**, **Alignment**, **Number** (Formatting), (Table) **Styles**, **Cell** (Properties) and **Editing** tools. The Ribbon can be minimized to show only the Tab titles (one of the selections in the drop down menu at the right of the **Quick Access Toolbar**). Other Tabs may appear as appropriate, e.g., a **Drawing Tools/Format Tab** appears when working with graphics.

1.3 Cells and their Contents

SELECT *cell*

CLICK on a specific cell; e.g.: SELECT **B5**.

CLICK-AND-DRAG, or SELECT *range*

point with the mouse (to a cell), click and hold the mouse button down, scroll with mouse to the cell location where you want to end your selection and release the mouse button. This action selects a *range* of cells.

e.g.: SELECT **B5:D12**.

The same result is also achieved by CLICKING **B5**, holding down the [SHIFT] key, and then CLICKING on **D12**.

SELECT _____ Menu (Excel 2003)

point with the mouse to the desired menu at the top of the Excel window (workspace), hold the mouse button down, scroll down to the desired menu item on the drop-down menu, release the button. e.g.: SELECT MENU/INSERT.

SELECT _____ Tab (Excel 2007 onward)

CLICK the desired TAB in the Ribbon at the top of Excel window (workspace) e.g.: SELECT INSERT Tab.

CONTROL-CLICK on various cells.

pressing the [CONTROL] key while selecting various cells selects each cell individually, adding each individual selection to the total group. The cells do not need to be adjacent to each other. The selected cells are grouped so that they can all be formatted, copied, etc. at the same time.

1.2 EXCEL Interface

The overall layout – *workspace* – of **Excel 2003** and **Excel 2007** are shown in *Figs. 1a* and *1b*, and of **Excel 2010**, **Excel 2013** and **Excel 2019/365** are shown in *Figs. 2a*, *2b* and *2c* respectively.

A *cell address* – its column and row position – is given by its letter column (A, B, ... Y, Z, AA, AB, AC...), and its numerical row (1, 2, 3, ... 26, 27, 28...). Thus, **Cell B5** is in the second (**B**) column and in the fifth row (**5**). The 27th column is **AA**, followed by **AB**, etc.

A cell's address can be thought of as a variable name. The content of the cell is the *value* of the variable. Some types of content that can be entered in a cell are:

1. **Text**, e.g., Monday, Debits, Force.
In *Figs. 1* and *2*, **n** and **nx3** are *text*.
2. **Numbers**, e.g., 23, \$32, 14.26, 22-Oct-99, 2.45E+05, 2.45E-05.
In *Figs. 1* and *2*, the value of cell **A6** is 3.
3. **Formulas** define the value of a cell in terms of the values of other cells. A formula is always preceded by an equal sign, and may include *numbers*, mathematical *operators* (+, -, *, /, etc.) and *functions* (sine, cosine, summation, etc.). For example:

= A5*3

means take the number in A5 and multiply it by 3, as in *Figs. 1* and *2*.

= A1+B1-C2/3

add A1 and B1, and then subtract one-third of C2.

= A1*C3*SIN(B2)

A1 multiplied by C3 multiplied sin(B2); the angle in trigonometric functions must be in radians.

= SUM(A1:A5)

sum of the contents of A1, A2, A3, A4, A5; i.e., the *range* is A1:A5.

When a cell is *selected* (CLICK on the cell), it is the *Active Cell* (or *Selected Cell*). The active cell's content – text, number or formula – is displayed in the *Formula Bar*. The value (text or number) of the cell is still displayed in the cell itself.

The *selected* or *active cell* has a thick border, with a *Fill Handle* at its lower right (cell **B5** in *Figs. 1* and *2*). The cell's address is displayed to the left of the Formula Bar. The cell's column and row headings are also highlighted – the column heading (**B**) at the top of the worksheet, and the row heading (**5**) at the left.

With a cell selected, if you then **CLICK** in the Formula Bar, the formula becomes **color-coded**. Each cell address in the formula, and the border of the referenced cell, is shown in the same color. The color-coding helps the user visualize how the cells in the worksheet are related.

Also, if you **DOUBLE-CLICK** the cell, any formula in the cell will be displayed in the cell itself and color-coded.

1.4 Entering Contents

To enter a **text string**, **number** or **formula** into a cell, **SELECT** the cell (with the mouse).

Type the entry and then hit **[ENTER]** when you are done. What you type appears in the cell and in the Formula Bar. Hitting the **[ENTER]** key ends the entry; the cursor will automatically move down one cell.

You should be aware of the following:


- a **numerical entry** is considered as a *number* by Excel; numbers are by default *right-justified*.
- **to enter a number as text**, type the single quotation mark first, e.g.: **'2** ... the *number* will be made a *text* value (although it can still be used as a number); text is by default *left-justified*.
- **always enter an equal sign before any formula**.
- any entry that contains a non-number is considered *text*. Exceptions are:
 - when the entry is preceded by an equal sign (then it is a *formula*), or
 - if it is in scientific notation (e.g., 2.45E+05, which a computer reads as 2.45×10^5).

To edit the contents of a cell, **CLICK** on the cell, and then **CLICK** on the Formula Bar.

2.0 Tab Interface

The major change in the Microsoft Office Suite from **Office 2003** to **Office 2007/2010/2013** is that the **Ribbon** interface (Figs. 1b, 2) replaced the **Menu** interface (Fig. 1a). This change made the application features easier to access, instead of being buried in menus.

2.1 Microsoft File Tab

With **Excel 2010**, the **File Tab** replaced the **Office Button**  of **Excel 2007**, which itself had replaced the **File Menu** of **Excel 2003**. Clicking on the **File Tab** opens the menu shown in Fig. 3.

Besides the standard commands used for files, the **Excel Options** (at the bottom of the menu in Fig. 3), is used to customize the look of Excel, or to activate **Add-Ins** such as the data analysis tool **Analysis ToolPak**, and the **Solver** tool, both of which are discussed later in this text/course.

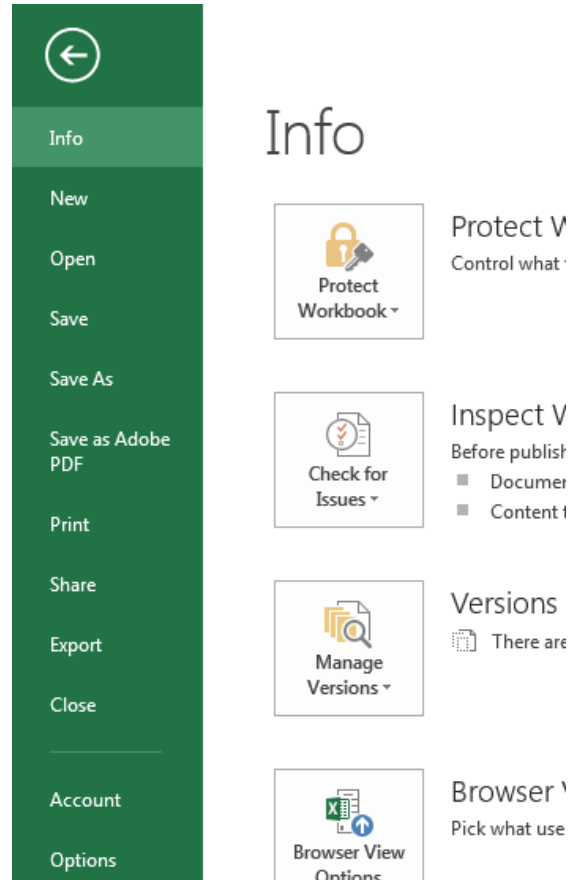


Fig. 3. Excel 2013 File Tab. (Excel 2010).

2.2 Ribbon and Tabs

The Ribbon is the primary method of accessing **Excel** tools and commands. There are eight default **Tabs** in the Excel Ribbon.

Each Tab is divided into several **Groups** of related Excel features. If there are more selections for a group, there is an arrow icon at the lower right of the group title (e.g., Fig. 4, **Clipboard** group). Clicking on the arrow opens up a **pane** (a sub-window within the Excel window), or a **Dialog Box**, with more options (Fig. 5).

Excel features and tools are selected by clicking the appropriate button on the Ribbon. By hovering the mouse pointer over a button, a brief description of what the button does is displayed.

One (sometimes confusing) aspect of the Ribbon is that what each Group area displays changes with the width of the Excel window. If the Excel window – and thus the Ribbon – is not very wide, you may only see icons or other reduced descriptions

The next few pages provide brief descriptions of each of the Tabs.

2.3 Home Tab

The *Home Tab* (Fig. 4) includes the most commonly used Excel features, which are listed in *Table 1*.

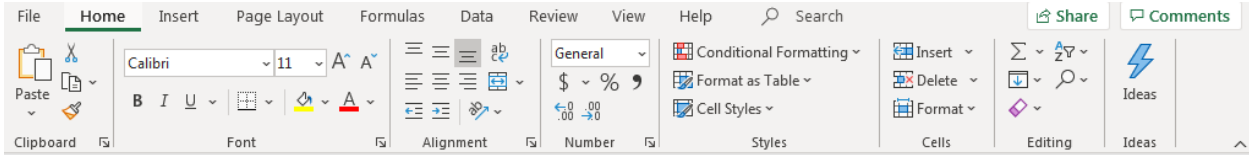


Fig. 4. The Home Tab (Excel 365).

Table 1. Home Tab Features and Tools.

Clipboard	<p><i>Cut/Copy/Paste</i> features.</p> <ul style="list-style-type: none"> The arrow under <i>Paste</i> will open up a drop-down menu. The arrow to the right of “<i>Clipboard</i>” will open the <i>Clipboard Pane</i>. The Clipboard is a temporary folder where copied text, images, etc., are stored.
Font (Fig. 5a)	Apply font Family, Style, Size, Bold/Italic/Underline, Color, etc. The pop-up window also provides access to other cell-formatting features (Borders, Fill, etc.).
Alignment	<p><i>Align</i> content of cell: top/middle/bottom; text direction; left/center/right justify; indents.</p> <p> <i>Wrap Text</i> <i>Text Wrapping</i> allows cell to automatically create more than one line of text, if necessary (the cell height grows with the content).</p> <p> <i>Merge & Center</i> <i>Merge Cell</i> combines two or more cells into one.</p>
Number (Fig. 5b)	Formats how a number is represented. Number of decimal places, Scientific Notation, Currency (with or without \$-sign), Percent, Phone Number, Special Format (e.g., place a “10/” in front of the numerical date to represent “October #”), etc.
Styles	Apply <i>Conditional Formatting</i> (e.g., change cell color if its content is a certain value). <i>Format as a Table</i> : a Table allows easier sorting and manipulation of data. <i>Cell Styles</i> (cell color, number style), etc.
Cells	<i>Insert/Delete/Format</i> individual cells, rows, columns, range, etc.
Editing	<p> <i>Fill</i> <i>Fill Cells</i> with active cell’s (cells’) formula, number, etc.</p> <p> <i>Clear</i> <i>Clear</i> contents of cell (including its formatting).</p> <p><i>Sort and Filter</i>: Sort and filter data.</p>
Ideas	Provides ideas of what your can do with your spreadsheet in its current form.

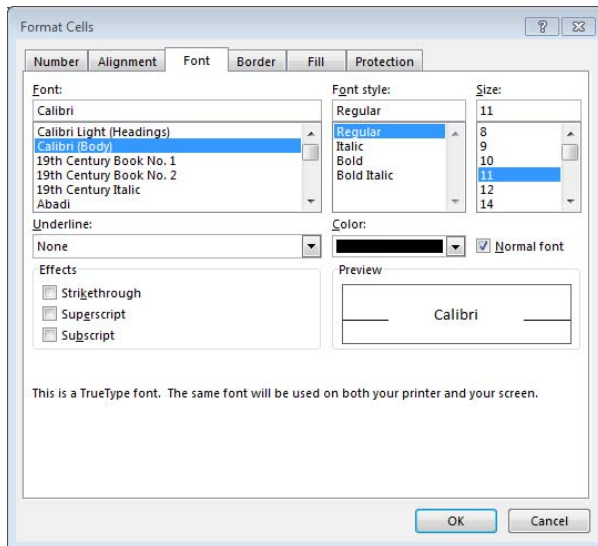


Fig. 5a. Format Cells dialog box: Font (Excel 365).

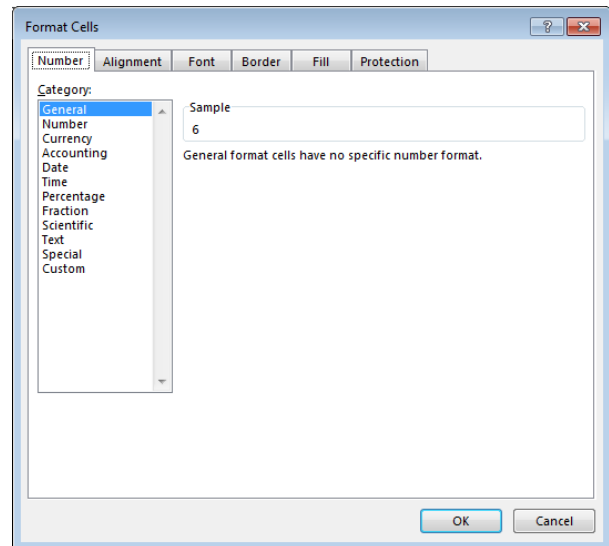


Fig. 5b. Format Cells dialog box: Number (Excel 365).

2.4 Insert Tab

The *Insert Tab* (Fig. 6) includes items that are commonly inserted into an Excel worksheet.

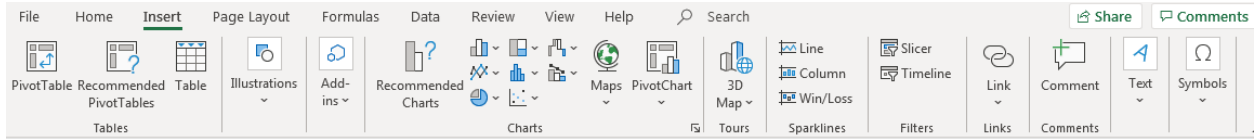


Fig. 6. The Insert Tab (Excel 365).

Table 2. Insert Tab Features and Tools.

Tables	The <i>Pivot Table</i> tool allows you to summarize data of a large data table. <i>Table:</i> Turn a range of cells into a table, with headers. A table is useful for sorting, filtering and formatting a related set of data.
Illustrations	Insert a <i>Picture, Clip Art, Shapes, SmartArt</i> (pre-designed flow-charts, organization charts, etc.) to help illustrate the spreadsheet.
Add-ins	Incorporate additional Excel or third-party apps into Excel.
Charts (Fig. 7)	Insert a <i>Chart</i> (e.g., a <i>plot, graph</i>).
Sparklines	Insert sparklines – small charts within single cells
Filters	Use a <i>Slicer</i> to filter data visually, or a <i>Timeline</i> to filter dates interactively.
Links	<i>Hyperlink</i> to a webpage, picture, or file.
Comment	Insert a comment; especially useful when sharing the Excel file.
Text	<i>Text Boxes, Headers/Footer, WordArt, Signature Line, Objects.</i>
Symbols	<i>Equations and Symbols</i>

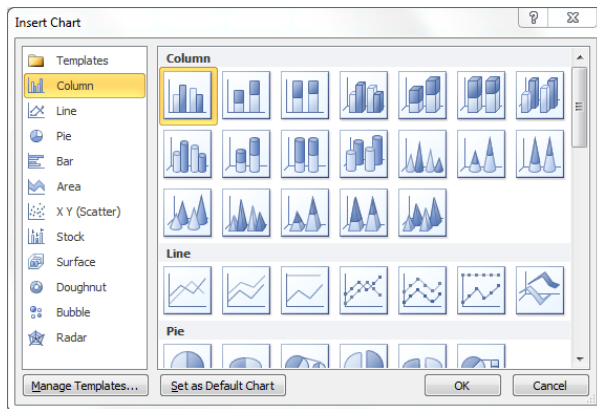


Fig. 7b. Insert Chart dialog box (Excel 2010)

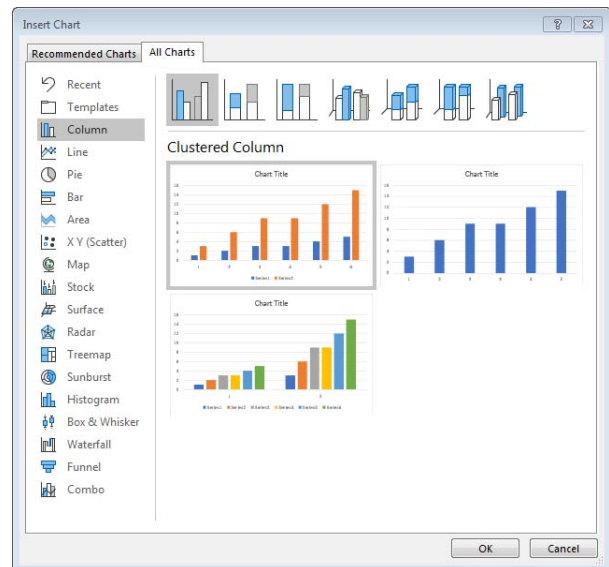


Fig. 7b. Insert Chart dialog box (Excel 365)

2.5 Page Layout Tab

The *Page Layout Tab* (Fig. 8) lists common page layout tools.

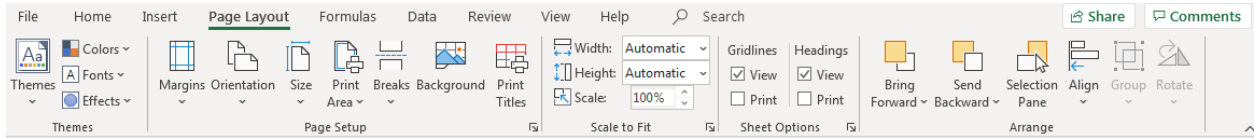


Fig. 8. The Page Layout Tab (Excel 365).

Table 3. Page Layout Tab Features and Tools.

Themes	<i>Set the overall look of the workbook –Color Combination, default Fonts, Effects (details in shapes of objects). A Theme helps keep everything in a document consistent. PowerPoint is a good example of where themes are used... with a few clicks, the Color/Fonts/Background of the entire document can be modified. A company/organization might decide to use a single theme for all of their Word, Excel and PowerPoint documents.</i>
Page Setup (Fig. 9)	<i>Margins: Set the white space between the text boundary and the edge of the paper, top/bottom/left/right. Orientation: Portrait/Landscape. Size: Select paper size. Print Area: Select/De-select range in worksheet that you want to print. Breaks: Insert/Remove Page Breaks. Background: Insert a background picture into the worksheet. Print Titles: Allows you to set rows in a worksheet (e.g., table headers) that will be printed at the top of every page, even when more than one page is printed.</i>
Scale to Fit	<i>Specifies size of printed output (number of pages wide, tall, scaling, etc.).</i>
Sheet Options	<i>View on Screen/Print Gridlines (gray borders around cells). View/Print Headings (columns/row headings).</i>
Arrange	<i>Order, Align, Rotate, etc., objects.</i>

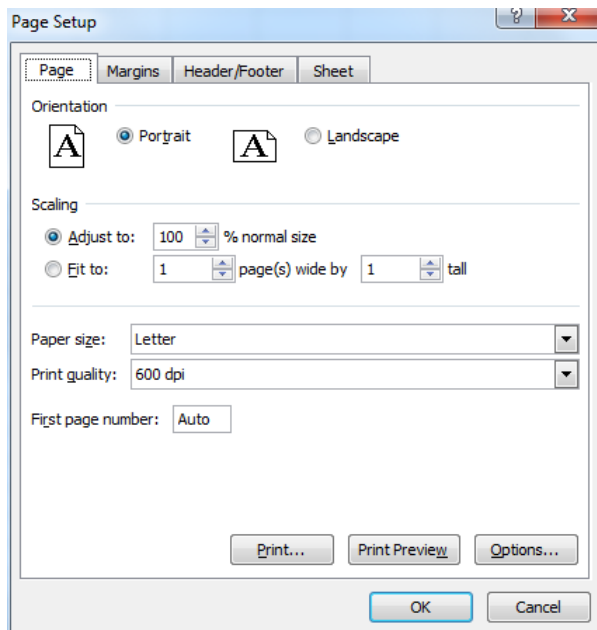


Fig. 9. Page Setup dialog box (Excel 2010, same for 365).

2.6 Formulas Tab

The *Formulas Tab* (Fig. 10) includes tools used to perform and check calculations.

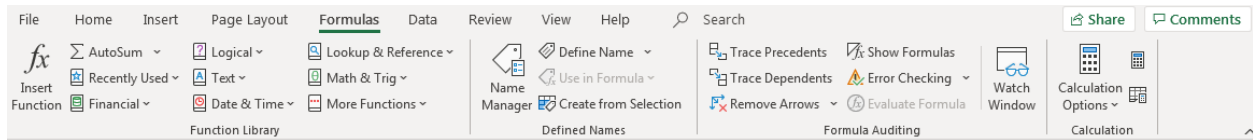


Fig. 10. The Formulas Tab (Excel 365).

Table 4. Formulas Tab Features and Tools.

Function Library	<p>While you can type formulas directly into the Formula Bar, it is often convenient to use the Function Library to find and select a function.</p> <ul style="list-style-type: none"> • <i>Insert Function</i> will give you access to all functions. Functions are also grouped by type (e.g., <i>Financial</i>, <i>Logical</i>, <i>Math & Trig</i>). • <i>More Functions</i> includes <i>Statistical</i> and common <i>Engineering</i> functions.
Defined Names	<p>A cell or a range of cells can be given a name; e.g., a cell containing the number 9.81 might be named “gravity”. Any formula in the worksheet with gravity in it will use the value from the cell named gravity. This makes referencing cells easier since the letter/number cell address need not be remembered.</p> <p><i>Name Manager</i> lists all the named cells and ranges.</p>
Formula Auditing	<p>This group shows the links between cells and provides formula checking.</p> <ul style="list-style-type: none"> • <i>Trace Precedents</i>: Arrows are drawn to the active cell <u>from cells</u> (precedents) that contribute to the active cell’s value. • <i>Trace Dependents</i>: Arrows are drawn from the active cell <u>to cells</u> (dependents) that are based on the value of the active cell. • <i>Show Formulas</i> (button to the right of Trace Precedents): The formulas in each cell are displayed (by default, the calculated values of each cell are displayed). • <i>Error Checking</i>: Checks for common errors in formulas. • <i>Evaluate Formula</i>: Allows trouble-shooting/debugging of a formula; opens a dialog box to evaluate individual parts of a cell’s formula. • <i>Watch Window</i>: Opens a small window that displays the value (and formula) of cells of interest. This is a very helpful tool; in a large worksheet, you can watch a particular cell’s value as you work/make changes elsewhere on the worksheet.
Calculation	<p><i>Calculation Options</i>: Specify to automatically calculate or manually calculate the worksheet after a change in a cell value.</p> <p><i>Calculate Now</i>: Calculates entire workbook – all worksheets (in manual calculation mode)</p> <p><i>Calculate Sheet</i>: Calculates current worksheet only (manual calculation mode)</p>

2.7 Data Tab

The *Data Tab* (Fig. 11) allows you to import and manipulate data.

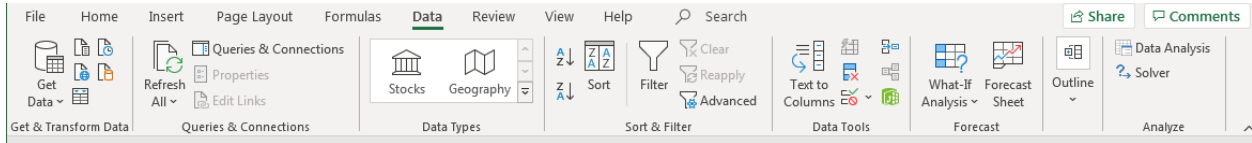


Fig. 11. The Data Tab (Excel 365).

Table 5. Data Tab Features and Tools.

Get and Transform Data	Acquire data from other programs, the web, from text files or other databases. Large amounts of data are effectively stored in text (.txt) files or comma separated values (.csv) files. Storing large amounts of raw data in an Excel file creates a very large file because formulas, formatting and other instructions require a lot of memory.
Queries and Connections	Data can reside outside the Excel file, and be accessed/linked so that data is available to Excel. Changes in the external file/database will be reflected in the Excel file.
Data Types	Acquire stock and geographic data via internet.
Sort and Filter	<i>Simple Sort:</i> Sorts selection from <i>lowest to smallest</i> or <i>highest to lowest</i> . Based on value (number or text) in first column of selection. Cells in each row of a selection stay together. <i>Sort:</i> Opens a dialog box for advanced sorting options (e.g., multiple sort categories). <i>Filters:</i> Reduce the amount of data displayed so you can focus on certain records (e.g., sort out day/temperature data for all days where the temperature was greater than 85 degrees; sort out students with a score of 75% or more).
Data Tools	<i>Text to Columns:</i> Breaks text up between columns. E.g., a column of cells might contain both first and last names. In databases, it is best to break first and last name data into two columns. <i>Remove Duplicates:</i> Removes records (row data) that are duplicate. <i>Data Validation:</i> Prevents invalid data from being entered into a cell (e.g., makes sure an entered number is a phone number, a non-negative value, etc). <i>Consolidate:</i> Combine values from two or more ranges into a new range.
Forecast	<i>What-If Analysis:</i> Compare results of various scenarios. <i>Goal Seek:</i> Specify the desired value of one cell by changing the value of another cell; this is a basic “solver” application. <i>Forecast Sheet:</i> Predict future data based on trend of worksheet data.
Outline	<i>Group/Ungroup</i> a range of cells so they can be expanded/collapsed/ hidden at once. <i>Subtotal:</i> Automatically sub-total/totals items; inserts rows with subtotal.
Analysis (enabled with Add-Ins)	<i>Add-Ins</i> are advanced tools that need to be activated in Excel via the FILE Tab/Options/ Add-Ins (Fig. 12). <i>Data Add-Ins</i> are added to the Data Tab. Two common Add-Ins for science and engineering are: <ul style="list-style-type: none"> • Analysis ToolPak: Statistical and Engineering Analysis. • Solver: Used to solve systems of equations and perform optimization.

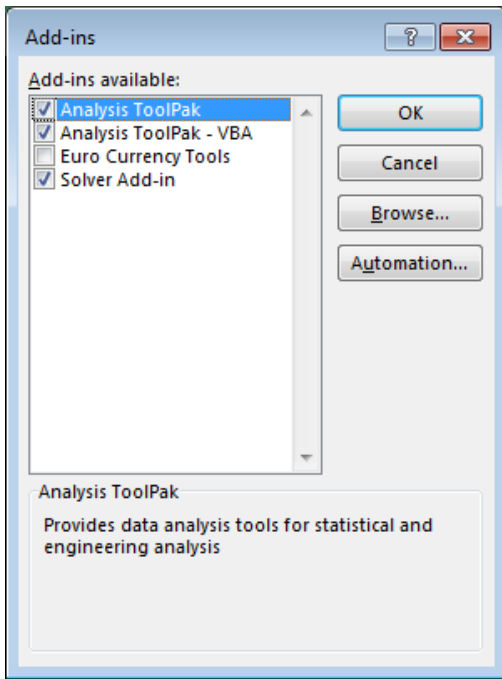


Fig. 12. Add-In Dialog Box (Excel 365).

2.8 Review Tab

The *Review Tab* (Fig. 13) allows you to proof, review, comment, share and protect the workbook.

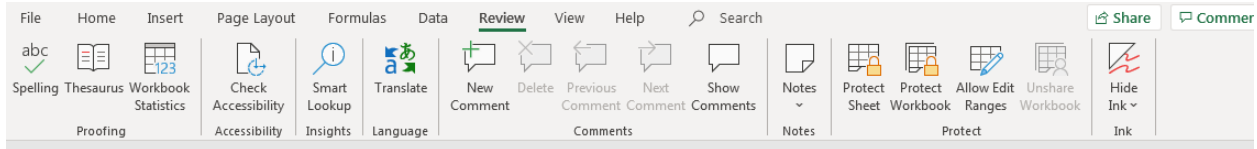


Fig. 13. The Review Tab (Excel 2010).

Table 6. Review Tab Features and Tools.

Proofing	Spell-checking and other grammar/language tools.
Accessibility	Helps you design your spreadsheet for those with disabilities.
Insights	Learn more about the text you select (links to internet)
Translate	Translate selected text into another language.
Comments	Allows another person to include comments (somewhat like a Post-It™ note).
Notes	At a note to the worksheet (somewhat like a Post-It™ note).
Protect	<i>Protect Sheet/Workbook:</i> Prevent changes from being made to a file except by authorized users. <i>Share Workbook:</i> Work with others on a network server. <i>Protect and Share:</i> Share file, but with a password. <i>Allow others to Edit Ranges.</i> Partially protected file. <i>Track Changes:</i> Record changes made to file.
Hide Ink	Hides inked comments/markings (does not delete them).

2.9 View Tab

The *View Tab* (Fig. 14) allows you to select how the workbook will be displayed on screen, and how it will be printed.

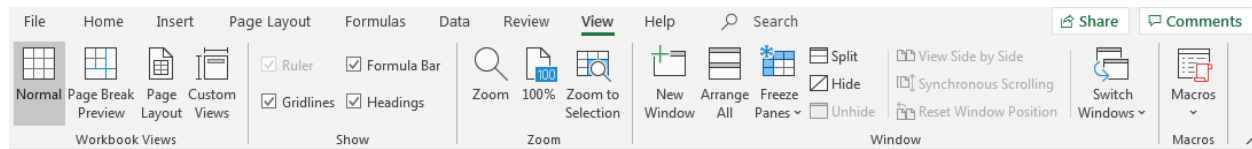


Fig. 14. The View Tab (Excel 365).

Table 7: View Tab Features and Tools.

Workbook Views	<p><i>Normal:</i> Shows workbook without page breaks.</p> <p><i>Page Layout:</i> Worksheets displayed on electronic “pages” as they will be printed.</p> <p><i>Page Break Preview:</i> Heavy Solid Blue lines indicate the region of the worksheet that will be printed. Heavy Dotted Blue Lines indicate page breaks. These boundaries can be moved using the cursor (CLICK-AND-DRAG).</p> <p><i>Full Screen:</i> Expands Workbook to fill screen.</p>
Show	Show and Hide <i>Rulers</i> , <i>Gridlines</i> (the gray cell-boundaries), the <i>Message Bar</i> , the <i>Formula Bar</i> , the <i>Column and Row Headings</i> , etc.
Zoom	<i>Custom Zoom</i> , <i>100% zoom</i> , or <i>Zoom to the Selection</i> of cells.
Window	<p><i>New Window:</i> Opens another Workbook in the overall Excel window.</p> <p><i>Arrange All:</i> Arranges windows horizontally, vertically, in cascade, etc.</p> <p><i>Freeze Panes:</i> Freezes a set of rows or columns on the worksheet while rest of worksheet can be scrolled through. This is very useful as text headings in a large table will always be on-screen.</p> <p><i>Split:</i> Splits worksheet into 4 panes so you can view various parts of the sheet at once.</p> <p><i>Hide:</i> Hides the current workbook.</p> <p><i>Unhide:</i> Display a hidden workbook.</p> <p><i>View Side by Side:</i> View two workbooks side-by-side or top-to-bottom (depending on selection in Arrange All).</p> <p><i>Synchronous Scrolling:</i> Scroll in two workbooks at once!</p> <p><i>Reset Window Position:</i> Resets the size of two workbooks being compared so that they are the same size (zoom) and aligned.</p> <p><i>Save Workspace:</i> Saves layouts of workbook windows.</p> <p><i>Switch Windows:</i> Switches active workbook.</p>
Macros	<i>Macros</i> are a set of recorded actions/commands that you wish to save and repeat over and over. If you use the same long custom formula again and again, a macro may save time.

2.10 Other Tabs

Other Tabs may appear on the Ribbon from time to time. These tabs are specific to the current mode. For example, when working with objects and figures, a **Drawing Tools/Format** Tab appears.

3.0 Formulas

Formulas, Operators, References and Functions

A powerful feature of Excel is that it can perform many mathematical operations at once, and continuously update results whenever the contents of one cell (used to calculate other values) changes.

3.1 Formulas

A *formula* is a mathematical expression that defines the value of a cell. Formulas can consist of referenced cells (precedents), numerical data, mathematical operators, and functions.

Formulas always begin with an equal sign. The value of a cell with a formula is based on the values of other cells that the formula references, e.g.; if in cell **C3**, you type:

= C1 + C2

then the value of cell **C3** is the sum of the contents of **C1** and **C2**.

If you neglect to enter the equal sign:

C1 + C2

then the content of **C3** is considered to be *text*. No calculation can be performed if the referenced cell has a *text* value.

3.2 Mathematical Operators

The standard mathematical operators are available:

Addition: **= C1 + C2**
add content of C1 to content of C2

Subtraction: **= D7 - B6**
subtract B6 from D7

Multiplication: **= E5 * E4**
multiply E5 by E4
= A5 * 3
multiply A5 by 3 (*Fig. 1*)

Division: **= E7 / E2**
divide E7 by E2

Exponent: **= E7 ^ 2**
E7²: E7 squared
= E7 ^ D2
E7^{D2}: E7 to the power of the value in D2

The **order** in which operations are done is as follows:

1. Parenthesis (inner to outer),
2. Exponent,
3. Multiplication and Division (left to right),
4. Addition and Subtraction (left to right).

This is the standard mathematical order of operations. You might recall the mnemonic PEMDAS (“Please Excuse My Dear Aunt Sally”). Note that Multiplication and Division have the same rank, as do Addition and Subtraction; one is simply the “opposite” of the other.

Be careful when entering a formula. If you want to divide **E3** by the sum of **E1** and **E2**, enter:

= E3 / (E1 + E2)

which tells Excel to add **E1** and **E2** first, then do the division. An incorrect formula would be:

$$= E3 / E1 + E2$$

which actually equals $(E3/E1) + E2$.

3.3 Parentheses

Parentheses group parts of a formula. Every *left parenthesis* must have a *right parenthesis* (Excel will give an error message if you do not have matching pairs). Make sure parentheses are in the right locations, for how they are nested is important in determining the order in which calculations are done; e.g.:

$$= B7+C3*D4$$

does not equal:

$$= (B7+C3)*D4$$

Excel provides some useful tools to help with parentheses. In the Formula Bar, when the right parenthesis of a pair is typed, the two parentheses marks temporarily boldface (flash). A parentheses pair also flashes when the text cursor is in the Formula Bar, and you use the Arrow Keys to move left/right over one of the parentheses.

Nested parentheses are color-coded: black, green, purple, brown, light green, orange, etc., from outer pair to inner pair.

HINT:

At first, using parentheses can be difficult. It is often a good idea to break up long formulas into several *steps* or *parts*, placing each step in a separate cell (or a separate column if operating on data that take up several rows). Each step in the process can then be checked. Breaking up the problem makes troubleshooting errors easier for long formulas.

HINT2:

While I have emphasized parenthesis, it is not necessarily to use them for every operation. For example:

$$= (B7+((C3*D4)*COS(E8)))$$

is the same as:

$$= B7+C3*D4*COS(E8)$$

On the other hand, some users may find the “unneeded” parentheses helpful in visualizing the equation.

3.4 Cell References

3.4.1 Local References

Consider typing the following into cell **C3**:

$$=C1*C2$$

Excel actually understands the *selected cell* (**C3**) to be the product of the value from two cells above the selected cell (**C1** is two above **C3**) and the value from one cell above the selected cell (**C2** is one above **C3**). In other words, the cells used in the calculation are specified *with respect* to the **C3**.

When a formula refers to cells *with respect* to the selected cell, the references are *Local References*.

If you now copy the formula in **C3** ([CTRL]-[C]) and paste it ([CTRL]-[V]) into another cell, say, **F6**, then the formula in **F6** will be:

$$=F4*F5$$

which is the product of the value from two cells above selected cell **F6** and the value from one cell above **F6**. The *local references* are now with respect to **F6**.

Local references are useful in many situations. Consider a set of data listed in cells **A4, A5, A6, A7, A8, A9** as in *Fig. 1* and *Fig. 2*. If each of these values is to be multiplied by 3, then the base equation can be entered in cell **B4**: $= A4*3$ (look at the cell the left and multiply its value by 3). The formula can then be copied down, as was actually done in *Figs. 1* and *2*.

On the other hand, copying formulas with *local references* can cause problems if you are not careful. A local reference may work in the original cell, but not in other cells. The solution is often to use *Absolute References*.

3.4.2 Absolute References

It is often desirable to use the same reference cell for one of the variables in a formula, no matter where you copy the formula to. Always referring to the same cell is an *Absolute Reference*.

Consider that **C1** holds a constant (like the acceleration of gravity) that is to be used in many cells in the spreadsheet. Consider typing into **C3**:

`=C$1*C2`

Excel now understands the *selected cell (C3)* to mean: **always take the value in C1 and multiply it by the value from one cell above the selected cell (C2 is one cell above).**

When copied to **F6**, the formula in **F6** will be:

`=C$1*F5`

Which is the product of absolute reference **C1** and the value of the cell one above F6 (F5 is one cell above).

The **dollar-sign \$** indicates an *Absolute Reference*. Wherever you copy the formula, the first term will always be **\$C\$1**.

NOTE: You might be thinking that a “constant” – a value used everywhere – does not change ... why not just type 9.81 into every equation that requires gravity. The answer is that the acceleration of gravity – although taken as a constant in a particular problem – may change value (e.g., on the moon or at higher earth elevations). You would have to change every equation with 9.81. By using an absolute reference, you would only need to change the content of a single cell.

Another advantage of putting a “constant” into its own cell is that the user can see (and easily change) what value is actually being used in the calculations.

3.4.3 Mixed References

You may place an absolute reference on only the **column**, e.g., **\$C1**, or on only the **row**, e.g., **C\$1**. The part of the cell address with the **\$-sign** is *absolute* and that without is *local*. For example, say the formula in cell **C3** is:

`=C1+C2`

The absolute reference is only on the column of the first term (column **C**). If this formula is copied to **F6**, then the formula in **F6** will be:

`=C4+F5`

Note the first term. The column reference is still **C**, since it is an *absolute reference* (always look in **Column C**). The row reference is now **4**, since it is a *local reference* (look two rows above the current cell, which with respect to **F6** is **Row 4**).

3.4.4 Name References

Instead of referring to a cell by its address, a cell can be *named*. If **C1** contains the acceleration of gravity, why not name **C1** “gravity”? as in (Fig. 15). Since the cell now has a unique name in the *workbook*, it is an absolute reference. Whenever **gravity** is used in an equation, it will reference the cell **C1**. Both of the following are the same:

`=C$1*C2`
`=gravity*C2`

To name a cell (or range of cells), **SELECT** the cell (or range), and the **CLICK** in the **Name Box** to the left of the Formula Bar.

A range of cells can also be named. The name would then refer to the entire range.

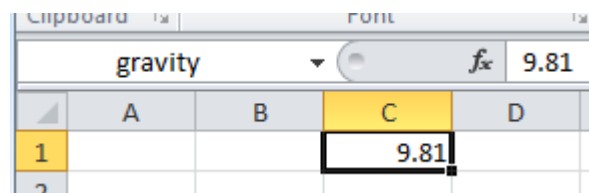


Fig. 15. Cell C1 is now named *gravity*, as shown in the Address Bar.

3.4.5 Referencing Cells in Another Worksheet

In some situations, a value in one worksheet needs to be used in another worksheet in the same workbook. This situation arises when “**Sheet1**” and “**Sheet2**” should be kept “separate”, but an output of **Sheet1** is an input of **Sheet2**.

Consider working in **Sheet2**, and it is desired to multiply the value in **C9** of **Sheet1** by 2. The formula in the Sheet2 cell would look like:

=Sheet1!C9*2

First, the sheet name is referenced, followed by an exclamation point, and then the cell: **Sheet1!C9**.

3.5 Reference Operators

You will often want to refer to more than one cell in a formula. This is accomplished by using the Reference Operators, as given in *Table 8*.

includes all cells **F12** to **H15**, inclusive (*Table 8, Figs. 1 and 2*). A range is one or more columns wide, and one or more rows tall (deep). A large number of values can be quickly referenced using the range short-hand notation.

The *range* and *union* operators are very powerful tools and a few words should be said about them here.

The *union* operator allows you to create a list of quantities (numbers, cells, ranges), which can be used in various functions.

A *range* specifies a rectangular block or array of cells. Range **F12:H15** is a rectangular block that

Table 8. Reference Operators.

Operator	Description/Example															
:	range of all cells between two reference cells, including those cells															
	=SUM(F12:H15) returns sum of contents of all cells between F12 and H15 , inclusive (see also, <i>Figs. 1 and 2</i>): <div style="margin-left: 40px;"> <table border="0"> <tr><td>F12</td><td>F13</td><td>F14</td><td>F15</td></tr> <tr><td>G12</td><td>G13</td><td>G14</td><td>G15</td></tr> <tr><td>H12</td><td>H13</td><td>H14</td><td>H15</td></tr> </table> </div>	F12	F13	F14	F15	G12	G13	G14	G15	H12	H13	H14	H15			
F12	F13	F14	F15													
G12	G13	G14	G15													
H12	H13	H14	H15													
,	union of two quantities (numbers, cells, ranges)															
	=SUM(C1:C3, gravity, 6) returns sum of all cells in range C1:C3 , the cell named gravity , and the number 6 .															
	=AVERAGE(C1:C3, gravity, 6) returns the average of all cells in range C1:C3 , the cell named gravity , and the number 6 .															
[single space]	intersection of two ranges															
	=SUM(C1:C3 A2:D4) returns sum of all cells in <u>both</u> range C1:C3 and range A2:D4 (here only C2 + C3). <div style="margin-left: 40px;"> <table border="0"> <tr><td></td><td>A2</td><td>A3</td><td>A4</td></tr> <tr><td></td><td>B2</td><td>B3</td><td>B4</td></tr> <tr><td>C1</td><td><u>C2</u></td><td><u>C3</u></td><td>C4</td></tr> <tr><td></td><td>D2</td><td>D3</td><td>D4</td></tr> </table> </div>		A2	A3	A4		B2	B3	B4	C1	<u>C2</u>	<u>C3</u>	C4		D2	D3
	A2	A3	A4													
	B2	B3	B4													
C1	<u>C2</u>	<u>C3</u>	C4													
	D2	D3	D4													

3.6 Functions

Functions are predefined formulas. For example, if you wanted to add the values in cells **C2, C3, C4, C5, ... C17, C18**. You could type the formula:

```
= C2+C3+C4+C4+C5+C6+C7+C8+C9+C10+C11+C12+C13+C14+C15+C16+C17+C18
```

However, a more efficient method would be to use the **SUMMATION function** and the **range C2:C18**.

```
=SUM(C2:C18)
```

All mathematical functions require an **argument** to operate on, i.e., one or more inputs. Thus, a set of parentheses always follows the function name. The argument(s) within the parentheses of a mathematical function can be a number, a cell and/or a range.

In Excel, there are a few exceptions to functions having an argument. For example, the value of π (pi) is the result of a function without an argument: **PI()**. The function **RAND()** returns a random number between zero and one. The parentheses must follow the function name, but there is no argument (the argument is the null set).

As you type a function into a cell, pop-ups appear that help remind you what argument(s) must be included in the function, which arguments are optional (in square brackets []), etc.

Function names in Excel are somewhat intuitive (e.g., **SUM, AVERAGE, COS**). When in doubt, a function can often be found by **SELECTING FORMULAS Tab/INSERT FUNCTION**.

The **Search Tool** in **Help** can be very useful for finding/learning about functions; e.g., search for "cosine". The result gives the definition of the function (more details are given for more complicated functions), as well as the proper **syntax** (form) to use in creating the function: **cos(number_in_radians)**.

Help's Search is also useful if you have some idea of what you want to do, but are not quite sure of the function name. For example, you might want to create a least squares linear fit for a set of data. Search for *least squares* to find related functions.

3.6.1 Some Common Functions

A brief list of common **Mathematical and Trigonometric** functions is given in *Table 9*; a fuller list is given in *Table 13*.

A brief list of **Statistical** functions is given in *Table 10*. A brief list of **Conditional** functions is given in *Table 11*.

Table 9. Some Mathematical and Trigonometric Functions.

number1 refers to a *cell address* (e.g., C5) with a numerical value, or an actual *numerical value* (e.g., 23); *number1, number2 ...* refers to a **range** (e.g., B2:D6, B2:B12, etc.) or a **list** (B2, B3, B4) of cells or numbers.

Function	Description/Example
=SUM(<i>number1, number2 ...</i>)	returns the sum of a list of arguments: <i>number 1, number 2, etc.</i>
	=SUM(A1:B3) returns the sum of the contents in all cells between A1 and B3, inclusive (A1+A2+A3+B1+B2+B3)
	=SUM(A1:B3, D4, 6) returns the sum of the contents in the range A1:B3, in cell D4, and the number 6
=SQRT(<i>number1</i>)	returns the square root of <i>number1</i>
=SUMSQ(<i>number1, number2</i>)	returns the sum of the squares of a set of numbers
=PI()	returns the value of π to 15 digits; yes, use an empty set of parentheses to indicate “function” π
=LOG(<i>number1</i>)	returns the log (base 10) of <i>number1</i>
=LN(<i>number1</i>)	returns the natural log of <i>number1</i>
=EXP(<i>number1</i>)	returns $e^{\textit{number1}}$
=DEGREES(<i>number1</i>)	converts <i>number1</i> in radians to degrees
=RADIANS(<i>number1</i>)	converts <i>number1</i> in degrees to radians
=SIN(<i>number1</i>)	returns the sine of <i>number1</i> ; <i>number1</i> in radians
=COS(<i>number1</i>)	returns the cosine of <i>number1</i> ; <i>number1</i> in radians
=TAN(<i>number1</i>)	returns the tangent of <i>number1</i> ; <i>number1</i> in radians
=ATAN(<i>number1</i>)	returns the inverse tangent of <i>number1</i> ; value in radians
=ATAN2(<i>number1, number2</i>)	returns inverse tangent of (<i>number2</i> / <i>number1</i>): <i>number1</i> is the <i>x</i> -value, and <i>number2</i> is the <i>y</i> -value. <u>Note:</u> ATAN(<i>number1</i>) actually has two solutions in 2π (360°), but Excel and your calculator only give one between $-\pi/2^\circ$ and $+\pi/2^\circ$; ATAN2 specifies the angle knowing the <i>x</i> - and <i>y</i> -values.

Table 10. Some Statistical Functions.

Function	Description/Example
=AVERAGE(<i>number1, number2...</i>)	returns the average of a list (range) of arguments
=MEDIAN(<i>number1, number2...</i>)	returns the median of a list (range) of arguments
=MODE(<i>number1, number2...</i>)	returns the mode of a list (range) of arguments
=STDEV(<i>number1, number2...</i>)	returns the standard deviation of a list (range) of arguments
=MAX(<i>number1, number2...</i>)	returns the maximum of a list (range) of arguments
=MIN(<i>number1, number2...</i>)	returns the minimum of a list (range) of arguments

Table 11. Some Conditional Functions.

Function	Description/Example
=IF(logical_test, value_if_true, value_if_false)	returns <i>value_if_true</i> or <i>value_if_false</i> depending on whether logical test is true or false
	=IF(B6<5, 0, "more") returns 0 if B6<5, otherwise returns more
	<i>Nested if example</i> =IF(B6<5, "small", IF(B6<10, "medium", "large")) returns small if B6<5, medium if B6<10, or large if anything else. <u>Note:</u> In this example, there are two <i>ifs</i> ; this is a nested conditional function; watch out for the parentheses!
=COUNTIF(number1, number2... , "value")	returns the number of entries in the <i>range</i> (or list) that equal the <i>value</i>
	=COUNTIF(B1:F3, "x") returns the number of cells in range B1:F3 with text value " x " in them.
	=COUNTIF(A4:A20, ">3") returns the number of cells in range A4:A20 with value greater than 3 .
=COUNT(number1, number2 ...)	returns the number of cells in a range that have numbers.
=COUNTA(number1, number2 ...)	returns the number of cells in a range that are <u>not</u> blank, including those with spaces <u>Note:</u> a cell with a <i>space</i> is NOT blank; a <i>space</i> is a character. To clear a cell, select it and hit [DELETE] or HOME Tab/EDITING/CLEAR
=COUNTA(number1, number2 ...)	returns the number of cells in a range that are blank (a space is not a blank).

3.6.2 Comparison Operators

Conditional Functions (*Table 11*) often require *Comparison Operators* ("equal to", "greater than or equal to", etc.). Comparison Operators are given in *Table 12*.

Table 12. Some Comparison Operators.

Operator	Meaning/Example
=	equal to
	=IF(B6>=70, "Pass", "Not Pass") returns Pass if B6 is greater than or equal to 70, else returns Not Pass
	=3=C5 returns TRUE if C5 = 3; returns FALSE if C5 is not equal to 3
	=3=2+1 returns TRUE
<>	not equal to
	=IF(B6<>8, 0, 1) if B6 does not equal 8, return 0 , else return 1
>	greater than
<	less than
>=	greater than or equal to
<=	less than or equal to

3.6.3 Text Operators

To *concatenate* two text values to produce a single value, use the ampersand, **&**. For example, if **A5** contains the text **Bull** and **A6** the text **dog**, then both of the following return **Bulldog**:

=“Bull”&“dog”
=A5 & A6

However, if you simply try to *add* **A5** and **A6** (or **Bull** and **dog**), **A5+A6**, Excel returns **#VALUE!** since you are trying to perform a mathematical operation on non-numerical values.

3.6.4 More Math Functions

More functions are given in *Table 13*. Some are more useful than others; the more obscure ones are given to give you a taste of the many functions that Excel has.

Table 13. Math and Trigonometry Functions. Do not forget the parentheses.

ABS returns the absolute value of a number	PI() returns the value of pi
ACOS returns the arccosine of a number	POWER returns the result of a number raised to a power
ACOSH returns the inverse hyperbolic cosine of a number	PRODUCT multiplies its arguments
ASIN returns the arcsine of a number	QUOTIENT returns the integer portion of a division
ASINH returns the inverse hyperbolic sine of a number	RADIANS converts degrees to radians
ATAN returns the arctangent of a number	RAND returns a random number between 0 and 1
ATAN2 returns the arctangent from x- and y-coordinates	RANDBETWEEN returns a random number between the numbers you specify
ATANH returns the inverse hyperbolic tangent of a number	ROMAN converts an Arabic numeral to Roman, as text
CEILING rounds a number to the nearest integer or to the nearest multiple of significance	ROUND rounds a number to a specified number of digits
COMBIN returns the number of combinations for a given number of objects	ROUNDDOWN rounds a number down, toward zero
COS returns the cosine of a number	ROUNDUP rounds a number up, away from zero
COSH returns the hyperbolic cosine of a number	SERIESSUM returns the sum of a power series based on the formula
DEGREES converts radians to degrees	SIGN returns the sign of a number
EVEN rounds a number up to the nearest even integer	SIN returns the sine of the given angle
EXP returns <i>e</i> raised to the power of a given number	SINH returns the hyperbolic sine of a number
FACT returns the factorial of a number	SLOPE returns the slope of a linear curve fit of <i>x-y</i> data points
FACTDOUBLE returns the double factorial of a number	SQRT returns a positive square root
FLOOR rounds a number down, toward zero	SQRTPI returns the (square root of the argument)*pi
GCD returns the greatest common divisor	SUBTOTAL returns a subtotal in a list or database
INT rounds a number down to the nearest integer	SUM adds its arguments
LCM returns the least common multiple	SUMIF adds the cells specified by a given criteria
LN returns the natural logarithm of a number	returns the sum of the products of corresponding array components (this is essentially the dot product)
LOG returns the logarithm of a number to a specified base	SUMSQ returns the sum of the squares of the arguments
LOG10 returns the base-10 logarithm of a number	SUMX2MY2 returns the sum of the difference of squares of corresponding values in two arrays
MDETERM returns the matrix determinant of an array	SUMX2PY2 returns the sum of the sum of squares of corresponding values in two arrays
MINVERSE returns the matrix inverse of an array	SUMXMY2 returns the sum of squares of differences of corresponding values in two arrays
MMULT returns the matrix product of two arrays	TAN returns the tangent of a number
MOD returns the remainder from division	TANH returns the hyperbolic tangent of a number
MROUND returns a number rounded to the desired multiple	TRUNC truncates a number to an integer
MULTINOMIAL returns the multinomial of a set of numbers	
ODD rounds a number up to the nearest odd integer	

3.7 Complex Numbers

Complex numbers must be dealt with using special functions. If you simply enter:

=SQRT(-1)

the result is: **#NUM!** which indicates that the function's argument is an invalid number. In ordinary mathematics, we cannot take the square root of a negative number. However, entering:

=IMSQRT(-1)

returns **6.1257422745431E-17 + i** (at least on my computer), or essentially **0 + i**.

Excel represents a complex number as a *text* value. The **IM**-prefix must be used to let Excel know to convert the text representation (e.g., *text 4+3i*) into the complex number.

Some Complex Number Operators are given in *Table 14*.

Caution: Excel is not the most effective tool to work with imaginary numbers. MATLAB is recommended.

Table 14. Some Complex Number Functions. See more in **FORMULAS/FUNCTION LIBRARY/MORE FUNCTIONS/ENGINEERING**. You must include the **IM**-prefix.

Function	Description/Example
=COMPLEX(<i>real_num</i>, <i>i_num</i>, [<i>suffix</i>]) the square brackets indicate the <i>suffix</i> is <u>optional</u> ; the <i>suffix</i> must be in quotation marks. The only practical option is "j" (engineers often use j as the imaginary number since <i>i</i> is for electric current).	creates a complex number : <i>real_num</i> is the real coefficient; <i>i_num</i> is the imaginary coefficient, and <i>suffix</i> is the imaginary number, <i>i</i> or <i>j</i> (the suffix must be in lower case, in quotation marks "j"). If the suffix is not included, the default is <i>i</i> . The complex number is left-justified; Excel treats the quantity as text unless IM -prefixed commands are used.
	=COMPLEX(1,0) returns 1
	=COMPLEX(0,1) returns i
	=COMPLEX(4,3) returns 4 + 3i
	=COMPLEX(4,3,"j") returns 4 + 3j
=IMABS(<i>comp_num</i>)	returns the absolute value (the magnitude) of complex number <i>comp_num</i> =IMABS(COMPLEX(4,3)) returns 5
=IMAGINARY(<i>comp_num</i>)	returns the imaginary coefficient of <i>comp_num</i>
=IMARGUMENT(<i>comp_num</i>)	returns the angle (<i>argument</i>) of <i>comp_num</i> in radians, from the real axis; angle = atan(imag/real)
=IMCONJUGATE(<i>comp_num</i>)	returns the complex conjugate of <i>comp_num</i>
=IMDIV(<i>comp_num1</i>, <i>comp_num2</i>)	returns the quotient of two imaginary numbers
=IMPRODUCT(<i>comp_num1</i>, <i>comp_num2</i>)	returns the product of two or more imaginary numbers
=IMREAL(<i>comp_num</i>)	returns the real coefficient of <i>comp_num</i>
=IMSQRT(<i>comp_num</i>)	returns the square root of a complex
	=IMSQRT(-9) gives 3i on my computer: 1.83772268236293E-16+3i = 0 + 3i
=IMSUB(<i>comp_num1</i>, <i>comp_num2</i>)	returns the difference of two or more imaginary numbers
= IMSUM(<i>comp_num1</i>, <i>comp_num2</i>)	returns the sum of two or more imaginary numbers <u>Note:</u> you cannot just add two complex numbers, e.g.: C1+C2 since Excel would treat the complex numbers as text unless the IM -prefix is included.
	=IMSUM(COMPLEX(3,1),COMPLEX(0,1)) gives 3+2i
	=COMPLEX(3,1) + COMPLEX(0,1) gives #VALUE! =COMPLEX(3,1) & COMPLEX(0,1) gives 3+ii (<i>text</i>)

3.8 Unit Conversions

When converting units, it is not always necessary to start from scratch as Excel already knows many of the standard conversions.

While you can convert degrees (say in cell **A6**) into radians by entering the basic equation:

$$=A6*(PI()/180)$$

You can also use the **RADIAN** function:

$$=RADIANS(A6)$$

Some Unit and Number System Conversion functions are given in *Table 15*.

Table 15. Some Conversion Functions.

Function	Description/Example
=DEGREES(number1)	converts <i>number1</i> in radians to degrees .
=RADIANS(number1)	converts <i>number1</i> in degrees to radians ; the argument of trig. functions in Excel must be in radians.
=CONVERT(number, "from_unit", "to_unit")	converts <i>number</i> of from_unit into to_unit .
	=CONVERT(1, "in", "mm") returns 2.54 .
	=CONVERT(1, "lbf", "N") returns 4.45 (2 dec. points).
	=CONVERT(1, "mi", "km") returns 1.61 .
=DEC2BIN(number, [places]) square brackets indicate <i>places</i> is <u>optional</u> .	converts a decimal (base 10) number into a binary (base 2) number. Optional places indicates the number of digits in the new system ... this provides <i>padding with leading zeroes</i> . If places is omitted, no leading zeroes are added.
	=DEC2BIN(15) returns 1111
	=DEC2BIN(15,6) returns 001111
=DEC2HEX(number, [places])	converts decimal (base 10) number into a hexadecimal (base 16) number
	=DEC2HEX(15) gives F (A=10, B=11 ... F=15)
=DEC2OCT(number, [places])	converts decimal (base 10) number into octal (base 8) number
	=DEC2OCT(15) gives 17
In general: =__2__ flip/combine DEC, BIN, OCT and HEX	Various conversions between decimal, binary, octal, hexadecimal number systems
=ROMAN(number, [form]) square brackets indicate <i>form</i> is <u>optional</u> .	returns Roman Numeral equivalent of decimal number . Form (0, 1, 2, 3, 4) is optional and specifies the type of numeral – classic (0 , default), or more concise (modern) versions
	=ROMAN(26) gives XXVI

3.9 Error Messages

Some common Errors that are displayed in cells are given in *Table 16*.

Table 16. Error Message.

Error	Description/Example
#####	the column is not wide enough for the number
#DIV/0!	attempting to divide by zero = 12/0
#N/A	value is not available to a function =CONVERT(1, "m", "sec") since dimensions are not the same.
#NAME?	<i>text</i> is in the formula; and the text value is not the name of a cell (range) =3*g where g is not defined
#NULL	specifying the intersection of two areas that do not intersect gives the <i>null set</i>
#NUM!	invalid number value in function = acos(2)
#REF!	cell reference is not valid; e.g., cells originally in a formula have been deleted For example, if cell F6 contains =3*H4 , and column H is deleted, the equation in F6 becomes = 3*#REF! . Even though old column I becomes new column H , the original cell that F6 pointed to no longer exists.
#VALUE!	wrong type of argument in function =B8+C8 where B8 and C8 contain text quantities or complex quantities

Notes