Introduction to Excel

In this class we will extensively use excel to perform repetitive calculations. We will also use excel to perform a simple form of data analysis which will allow us to evaluate whether the analytic formulas that we encounter in class fit the data we obtain from experiments and/or simulations.

Excel comes standard in many computers. If you don't already have it as City Tech. students you can download Excel, free of charge, through the college website. There are also numerous very similar freeware such as GoogleSheets and LibreOffice Calc. The basic functionality is very similar, but details of syntax and button arrangement vary.

Please use a computer. A tablet with an external keyboard and mouse should work too. Doing this with a touchscreen will be difficult.

Part 1 – Using formulas in Excel

You are likely familiar with the mathematical (as opposed to experimental) fact that the area of a

$$= \quad 2$$

Suppose we are given the following set of measurements for the diameter of a circle.

Diameter (m)	1.011	1.013	1.009	1.010	1.012	1.009

The "(m)" indicates that the measurement is given in meters.

Instead of typing the same formula, into a calculator, applied to the six different radii, we will use Excel, which will require us to enter the formula only once. Of course, we will still need to enter the data, i.e. the six diameters. To make the exercise a bit more interesting, do not use the values listed above. Each student should make up their own numbers for the six diameter values. If you have some familiarity with Excel, you can skip the detailed walkthrough and use your own diameter values to create a table similar to the figure below, with radius and area values computed. After that skip to Exercise 2.

- Create a new document in Excel.

- It is good practice to label the columns using the first row. In cell "A1," enter "Diameter (m)." In cell "B1," enter "Radius (m)." In cell "C1," enter "Area (m^2)." The symbol "^" $m2$. Note that in addition to the quantity we measured, we listed the units of the measurement in parentheses.

- The values of the diameter are entered into column "A" as you see above.

- The radius is half the diameter. Therefore, in cell "B2," enter "= A2/2." **Make sure to include the equals sign**. It tells Excel that what follows it is a formula as opposed to text or numbers. The "A2" is a reference to cell "A2" and Excel will use whatever data is in cell "A2" for the computation.

- In cell "C2," enter "= pi (π)*B2^2." The "*" symbol is multiplication, while the "^" means "raise to the power of." "pi (π)" is the way to enter π = 3.14... into Excel. The parenthesis indicate that "pi (π)" is treated as a function in Excel. Do not use "3.14" instead if "pi (π)." This numerical value is accurate only to 3 significant figures. The data in the example has 4 significant figures. (More on this later.) (Note that we could have omitted the radius column and entered " = pi (π)*(A2/2)^2.")

- Note that Excel automatically displays rounded numbers to fit the current width of the column. However, the full number is used in calculations. (If the column is made too narrow even to display rounded number, it will display #####.)

- We do not have to manually enter in anything else to finish the calculation. Select cell "B2" and "C2" together (click on "B2" and hold left mouse button as you drag curser to "C2." Release mouse button once both cells are selected.) Hover the curser at the bottom left corner and you should see a black "+." (If you are not in exactly the correct spot, you might see a white plus outlined in black or a cross with arrows. You don't want either. Position your curser precisely on the left bottom corner until you see a black "+.") Press and hold the left mouse button and drag the curser through the last row you want to compute.

- You should now have numbers in all three columns. If you click on any cell, you will see that it contains the formula you entered in the second row, but the formulas in each row references the cells in that row.

Part 2 - Graphing in Excel

Our next goal is to create some graphs. In future classes, we will use the graphs to investigate the relationship between experimental (or simulated) data and analytic formulas.

Create a graph with the area on the vertical axis and the radius on the horizontal axis. (Your math class likely referred to the vertical axis as the "y-axis" and to the horizontal axis as the "x-axis." Excel also uses this designation in some places.)

- Click on an empty cell (to make sure nothing is selected). Click "Insert" at the top. In the middle of the toolbar is the "Charts" tool bar. In this class we will (probably) always use "scatter plot," which can be found as the plot with a collection of dots just above the word "Charts". (It is next to the pie charts.) Click the scatter plot symbol and a drop-down list of scatter charts will appear. Select the first one, which has only dots. You will see a blank rectangle.
- Right click inside the rectangle and choose "select data." Click "add data." It's a good idea to name your graph. Enter a name into the "series name" slot. Suggestion: "Area as a function of radius". Click on the arrow near the "series x-values" window, use your

mouse to select the cells of the radius column. Hit "enter." Click on the arrow near the "series y-values" window and use your mouse to select the cells of the area column. Hit "enter." Click "ok" twice.

Part 3 – Adding a Trendline to Fit the Data

Can you guess what shape fits these points? If you don't see it immediately think about the function that was used to obtain the area from the radius.

Excel does not know the function that was used to create the data (it cannot extract this information from the formulas used to create the numerical data.) It can, however, perform a calculation to find this function based on the data. This is called "fitting" the data.

- Right click on one of the points of your graph and choose "add trendline." Choose "polynomial." Select "2," Check off "display equation" and "display R-squared." You should now see a curved line passing through all the points.

$2+$ $+$. And the equation $R^2 = 1$. We will not get into the mechanism of how Excel fits data. However, R^2 is an indicator of how well the function fits the data. Its value is always between 0 and 1, where 0 means data and function have no correlation and 1 means data and function was generated by a formula, and Excel found the right formula. (Note that the values of B and C are essentially 0.)

2?

Part 4 – Making a New Variable to Make the Equation Linear

Add a column to your table. Compute the diameter squared in this column. Insert another scatter chart, with the area values on the vertical axis again, and the newly created diameter squared values on the horizontal axis. Name the series something like "area as a function of diameter squared," Add a trendline and display the equation. Choose linear fit option.

 is the diameter squared here. The area is linear as a function of this conveniently chosen $=$ $=$.

?

 is also called the slope.

Comparing the Trendline Equation with Formula

   $=$ *2* in terms of the diameter, $=$ */2*. Rename   *2* as   . Rename   as y.

Fitting a straight line is computationally easier and produces more accurate results. We will often use the above trick of creating a convenient variable so that the function is linear in terms of this variable.

Part 5 – Inverting a Linear Relationship

Insert another scatter chart, but this time switch axis. Use the diameter squared values on the vertical axis and use the area values on the horizontal axis. Name the series something like "Diameter squared as a function of area." Add a trendline and display the equation. Choose linear fit option.

Notice the relationship remains linear when the variables switch roles.

Question 4: What is the value of the slope in this graph?

Question 5: How can this slope be expressed in terms of π? (Hint: Take the formula obtained in is the new slope.

Part 6 – Labelling Graphs

To make our graphs understandable to someone else or even to ourselves, we need to label them.

Select the first plot you made (the parabola). Right click on the plot and choose "format plot area." (Be careful not to click on the points or line, since that will take you to different menu. But also make sure to click in the plot area as opposed to edges of the chart window.) Click the green cross in the upper right of the chart window. Make sure the following are check-marked: axes, axes titles, chart title, gridlines, trendline. Click on the text next to the axes, or on the title, in order to change them. Click on the arrow next to "gridlines," to see horizontal and/or vertical gridlines. You should also see a menu titled "Format Plot Area" on the right side of your screen. There are lots of other options you can play with if you like. You should already have your title, but you can adjust it or add it now as well. The axes titles should state what the corresponding variables are and the units.

You do not need to label your other graphs. Note that if you right click on the equation of the trendline, and select "format trendline label," you can see choices about the presentation of the equation. If you want to change the trendline itself, then right click on the line and choose "format trendline."

Report Guidelines

Your report should consist of an Excel file and a .doc file or similar.

Put answers to questions 1 through 5 in the document file. On this occasion, you may also handwrite the answers, especially if you want to show work. However, for this particular report, you are not required to show how you got the answers.

The Excel file should contain the table with four columns and three graphs described above.