Excel Programming and Automation

Jonas Moss

12/12/22

Table of contents

Introduction

Welcome to the course ELE 3915 Excel Programming and Automation. You're about to get your hands dirty! This course is about being able to do cool things Excel and TypeScript. It should give you the confidence to assert that you can program in Excel. And it gives you an introduction to TypeScript, a popular general-purpose programming language used in Microsoft Office on the web. The slides can be found on Github, in the `slides` directory.

If you need to get in contact with me, please send an e-mail to `jonas.moss@bi.no`. I do not check It's learning often.

> ⚠ Warning
>
> This webpage is being continuously updated during. Most of the chapters are not finished.

Rough structure

The course is split into into four parts.

1. **Lecture 1–3**. Basic Excel usage, including formulas such as `SUM` ,`COUNTIFS`, `INDEX`, and `MATCH`. We focus on general mathematical formulas and data manipulation, in addition to simple formatting. Roughly speaking, these lectures cover the sort of Excel you should expect to see in lecacy Excel sheets. Most of the curriculum is covered on the excellent webpage ExcelJet.
2. **Lecture 4–6**. These lectures covers modern Excel formulas using dynamic arrays, `LAMBDA` and `LET`. Many of these features are just a couple of years old (as of 2023). I would not expect most employers to know about them. These features can do quite a bit of what Visual Basic for Applications (VBA) did in legacy worksheets. Programming using `LAMBDA` and `LET` is difficult, so make sure you take the exercises seriously. Again, most of the curriculum is covered on ExcelJet.
3. **Lecture 7–9**. Covers power query, power pivot, and DAX. These are modern tools for data visualization, data cleaning, and data manipulation. These tools are likely to form the core of your automation in Excel. They are widely regarded as the most important tools in the Excel analysts toolbox.

4. **Lecture 10–14**. These lectures contain an introduction to TypeScript and its application in Excel. Take note that we assume no previous exposure to programming in this course. TypeScript is a *typed* modification of JavaScript, the dominant language in web development, and has application far beyond Excel. The lectures will focus on programming in TypeScript in general, and the emphasis is on exercises.

A note on difficulty

Most of the course is about programming. Students often find programming hard. **Don't expect to be able solve every exercise in 5 minutes!** Solving programming exercises often take a long time, and you need to persevere.

Be aware that the difficulty of this course is uneven. For instance, lectures on `LAMBDA` and `LET` are harder than the first three lectures, and the lectures on power query are likely to be easier. Do not think this course will be a walk in the park.

To become a decent programmer it's a good idea to

1. Do a lot of exercises.
2. Spend at least 20 minutes on each exercise before you give up. You need to think really hard. Don't expect to be able to solve the problem without making an effort.
3. Do the exercise yourself after you have looked at the solution! Close the window and do it from memory. It's also a good idea to revisit the same exercise later on, e.g. the next day, to make sure you're able to do it.
4. Tinker around, either modifying exercises yourself, or with your own ideas. If your tinkering leads to something cool, tell me! Use Kaggle to download data sets to tinker with and Mockaroo to generate fake but plausible-looking data sets.

Do not to spend an inordinate amount of time on an exercise before you check the solution. If you have spent 1 hour on an exercise and haven't gotten anywhere, it might be smart save yourself some time and look at the solution.

Moreover, be aware that programming is often *extremely frustrating*. It's like talking to someone who just simply refuses to understand what you're saying, no matter how many times you repeat yourself. **It's normal and expected to feel frustrated**!

There are many tips online about learning to program, e.g., this collection of tips. But it mostly boils down to spending a lot of time solving problems.

About this site

Curious how this site was made? It is written using Quarto books.

1 Excel basics (i): Introduction to formulas

Last updated: 03.01.2023

1.1 Curriculum

- Basics of Excel, including cells, active cells, and ranges. Worksheets, basic formatting, data types and blank cells.
- Understanding what formulas and functions are, including copying of formulas using relative references.
- Reading the signature and short documentation of functions inside Excel.
- Using flash fill.
- Using the operators `+`,`-`,`/`, and `*`.
- A couple of keyboard shortcuts.
  - Press F2 to edit a cell and see its dependencies.
  - Press escape to exit editing a formula.
  - Press tab to auto-complete a formula.
  - Press SHIFT to add contiguous cells to a selection.
  - Press CTRL+DOWN to go to the last non-blank cell in a contiguous column. And CTRL+UP to go to the first column-wise, CTRL+LEFT-ARROW to go to the first row-wise, and CTRL+RIGHT-ARROW to go to the last row-wise.
  - Hold CTRL to add cells to a selection.
  - Press F4 to taggle absolute references.
- Logical values; the functions `AND`, `OR`, `NOT`, and the operators `=`, `<`, `>`, `<=` and `>=`.
- Overview of error messages.
- Knowledge of the basic datatypes of Excel (number; text; logical; error; array), including how to use the `TYPE` function.

Basic functions using one range as argument.

Name	Description
SUM	Sum all numbers in a range.
PRODUCT	The product of all numbers in a range.
MAX	The maximum of numbers in a range.
MIN	The minimum of numbers in a range.
COUNT/COUNTA/COUNTBLANK	Count the number of cells in a range that contain numbers (COUNT), are non-empty (COUNTA), or empty (COUNTBLANK).
ROWS / COLS	Counts the number of rows / columns in a reference.
AVERAGE	The average of the numbers in a range. Empty cells are ignored.
MEDIAN	The median of the numbers in a range.
STDEV	The standard deviation of the numbers in a range. Empty cells are ignored.
COUNTIF	Counts cells satisfying a criterion.

1.2 Lectures and exercises

Remember to look at the solutions only after giving the exercises a serious attempt. Solve the exercises yourself after looking at the solution.

The lecture slides are here. The Excel sheets used in the lecture, before being filled in, here. The lecture notes after being filled in are here.

Here are the exercises; the solutions can be found here.

1.3 Recommended resources

There are many excellent video resources for Excel online. The content of this lecture is pretty standard stuff, and there are probably 100s of Youtube videoes covering essentially the same content. For instance, the formulas covered in this lecture are also covered by Kevin Stratvert

here, but he goes a little further, covering harder formulas too. Leila Gharani introduces formulas here.

There are many introductions to flash fill too, e.g. this one.

There is a staggering number of shortcuts in Excel, see e.g. here. It's easy to get overwhelmed by shortcuts, so make sure you don't try to learn too many at once though!

2 Excel basics (ii)

2.1 Curriculum

2.1.1 Absolute and relative references.

- Understand the difference between absolute, mixed, and relative references and when to use each.
- Use F4 to cycle between the different kinds of references.
- `LARGE` and `SMALL` functions.

2.1.2 Conditionals in Excel.

- Understand conditional formulas and their uses, such as the `IF` function, nested `IF`s, and the `IFS` function.
- Learn the conditional aggregation functions such as `SUMIF`/`SUMIFS`, `COUNTIF`/`COUNTIFS`, and `MINIFS`/`MAXIFS` functions.

2.1.3 Additional mathematical functions

- Most of the math functions are relevant to us. We won't cover all of them in detail. Here is a list of particularly important functions.

Name	Description
`ABS`	Find the absolute value of a number.
`EXP`	Find the value of e raised to the power of a number.
`LOG`	Get the logarithm of a number.
`FLOOR.MATH`	Round number down to nearest multiple.
`CEILING.MATH`	Round a number up to nearest multiple.
`ROUND`	Round a number to a given number of digits.
`COMBIN`	Get number of combinations without repetitions.
`MOD` / `QUOTIENT`	Get the remainder from division / Returns the quotient without a remainder.

Name	Description
POWER / ^ operator / SQRT	Raise a number to a power or calculate the square root.

- Learn about how and when to use the SUMPRODUCT function.

2.1.4 Working with text

- Understand the use of the & operator for concatenation.
- Learn to solve basic text manipulation tasks.
- Get an overview of the text manipulation functions in Excel and how to apply them.

Name	Description
TRIM	Remove extra spaces from text.
TEXTBEFORE / TEXTAFTER	Extract text before / after delimiter.
EXACT	Compare two text strings, taking case into account.
SUBSTITUTE	Replace text based on content.
LOWER/UPPER	Transform text to lower/upper case.
PROPER	Capitalize first letter of each word in text.
CONCAT / TEXTJOIN	Join text values with(out) a delimiter.
LEN	Get the length of the text
LEFT / MID / RIGHT	Extract text from the left/middle/right of a string
FIND	Get location substring in a string.
REPLACE	Replace text based on location.

- Note that not all useful text manipulation tools are built-in and some tasks, such as counting the number of words in a text, may require creating custom functions.
- Some of the functions are outdated. You will see them used, but modern alternatives are better. This is arguably the case for LEFT; MID, and RIGHT, FIND and SEARCH. The modern variants will be covered in later lectures.

2.2 Lectures and exercises

The Excel sheets used in the lecture, before being filled in, here. The lecture notes after being filled in are here. Here are the exercises; the solutions can be found here.

2.3 Recommended resources

The YouTuber Chandoo discusses the text manipulation functions at length, so does the YouTuber Leila Gharani Leila Gharani. There are many good videos about these topics, and I strongly encourage you to explore them.

3 Excel basics (iii): Lookups and aggregation

3.1 Curriculum

3.1.1 Lookup, aggregation, and filtering.

- Knowledge of the `INDEX` functions, `XMATCH` function, and how they work together.
- Understanding the modern look up function `XLOOKUP`.
- Some uses of the important functions `UNIQUE` and `FILTER`.
- Using `FILTER` in data aggregation tasks.
- Gain an understanding of how to use the lookup functions, `FILTER`, and `UNIQUE` to perform tasks of intermediate complexity.

3.1.2 Miscellaneous

- Introduction to data tables. This article contains more information than I went through in the lecture, and you should read it.
- We have a cursory look at conditional formatting and very basic charts.
- In addition, we consider basic use of data validation, i.e., making drop down lists.
- Ranking and ordering using `RANK.EQ`, `RANK.AVG`, `SORT`, and `SORTBY`. Knowledge of sorting using Excel buttons.

3.2 Lectures and exercises

The Excel sheets used in the lecture, before being filled in, here. The lecture notes after being filled in are here. Here are the exercises; the solutions can be found here.

3.3 Recommended resources

The Wise Owl Training site has several exercises on lookup functions. They also have exercises covering other Excel topics.

You will be exposed to the function `VLOOKUP` outside of this course. It's worth it to spend some minutes understanding the difference between `XLOOKUP` and `VLOOKUP`, see e.g. this video.

Data validation and conditional formatting are bigger topics that it would seem from our coverage. You can read more about them on ExcelJet or elsewhere.

4 Programming in Excel (i): Introduction to `LAMBDA`

4.1 Curriculum

- How to define your own functions using `LAMBDA` and why it is useful.
- Using the name manager.
- Introduction to the Advanced Formula Environment, with emphasis on how to write documented and reusable code using the module functionality.
- Construction of custom arrays with `{}`.
- What a dynamic arrays, what the `#SPILL!` error means, and how to use dynamic arrays are ranges.
- Extending the basic Excel functions with `MAP`, `BYROW`, `BYCOLUMN`.
- Exercise in making custom functions using the tools we have learned until now.
- Making random numbers using the function `RANDARRAY`.

4.2 Lectures and exercises

The Excel sheets used in the lecture, before being filled in, here. The lecture notes after being filled in are here. Here are the exercises; the solutions can be found here.

4.3 Recommended resources

5 Programming in Excel (ii): Array functions, `LET`, and `INDIRECT`.

> **!** Important
>
> This page is ***not finished***, but might contain notes from the course developers. The curriculum, exercises, and recommended resources listed on this page is subject to change.

5.1 Curriculum

1. Make array constants using `{...}` Array constants are custom made arrays. They be rows, columns, or two-dimensional. *Links:* Lecture notes, exercises, and video.
2. Keep or remove rows/columns with `TAKE` and `DROP`. *Links:* Lecture notes, exercises, and video.
3. Select rows or columns using numerical indexing with `CHOOSEROWS` and `CHOOSECOLS`. *Links:* Lecture notes, exercises, and video.
4. Manipulate array dimensions with `TOROW` and `TOCOL`. `TOROW` transforms an array to a row and `TOCOLS` transforms an array to a column. These are useful for presenting data. They are important when creating functions, as some functions such as `FILTER` do not always work as intended when applied to two-dimensional arrays. *Links:* Lecture notes, exercises, and video.
5. Construct arrays with `HSTACK` and `VSTACK`. `HSTACK` stacks arrays horizontally and `VSTACK` stacks arrays vertically. These functions are especially handy when making functions. *Links:* Lecture notes, exercises, and video.
6. Make arrays more presentable with `WRAPCOLS` and `WRAPROWS`. *Links:* Lecture notes, exercises, and video.
7. Make formulas shorter with `LET`. The `LET` lets us define *local variables*, helping us reduce repetition in formulas. *Links:* Lecture notes, exercises, and video.

8. Make complex functions with `LET`. The `LET` function is especially useful when making functions. We'll have a look at several examples. *Links:* Lecture notes, exercises, and video.
9. Use the `INDIRECT` function to turn text into references. *Links:* Lecture notes, exercises, and video.
10. **Application:** We define our own variant of the net present value function, called `NPV` in Excel. *Links:* Lecture notes, exercises, and video.
11. **Application:** Summarizing tables with drop-down lists. *Links:* Lecture notes, exercises, and video.

5.2 Lectures and exercises

The lecture notes and videos for each curriculum point can be found above. Some simple exercises associated with the videos are also found above. Additional exercises are here, with solutions.

6 Programming in Excel (iii): Applications

> **!** Important
>
> This page is ***not finished***, but might contain notes from the course developers. The curriculum, exercises, and recommended resources listed on this page is subject to change.

6.1 Curriculum

Excel is equipped with many functions for handling dynamic arrays and `LAMBDA` functions. The most important are `FILTER`, `MAP` (and its cousins `BYCOL`, `BYROW`, and `MAKEARRAY`), and `REDUCE`.

To use `FILTER`, `MAP`, and `reduce`, we will need convenience functions such as

6.2 Exercises

6.2.1 Utility functions

We have discussed

Recall that `FILTER` does not take the same sort of arguments as e.g. `MAP`. Its second argument is an array of truth values, not a `LAMBDA` function. That is OK, but it's inconsistent with most ofther functions of dynamic arrays. Make a function

- `FILTER_(array; lambda)` Returns the array consisting of elements from `array` where `lambda(x)` is `TRUE`.
- `TAKEWHILE(array; lambda)` Takes elements from `array` until the `LAMBDA` function `lambda` returns false.
- `MAPWHILE(array;mapper;predicate)` Maps `mapper` onto array untile the `predicate` function returns `FALSE`.
- `FILTERBY(out;filter_array;lambda)` Returns the array consisting of elements from `out` where `lambda(x)` evaluates to `TRUE`.
- `ENUMERATE(array)` Takes a one-dimensional array (a column) merges it with `SEQUENCE(R)`, yielding a two-dimensional array.

6.3 Recommended resources

7 Power pivot and DAX

> **!** Important
>
> This page is ***not finished***, but might contain notes from the course developers. The curriculum, exercises, and recommended resources listed on this page is subject to change.

7.1 Curriculum

7.2 Exercises

7.3 Recommended resources

8 Typescript (i)

> **!** Important
>
> This page is ***not finished***, but might contain notes from the course developers. The curriculum, exercises, and recommended resources listed on this page is subject to change.

8.1 Curriculum

- **Primitive JavaScript values.** A list can be found here.
  - `Undefined` and `Null`.
  - Core primitives: `Boolean`, `Number`, and `String`.
  - Specialized: `BigInt` and `Symbol`.
- **Arrays:** Unnamed collection of objects.
- **Functions:** Takes input vales and does something with them.

8.2 Exercises

8.3 Recommended resources

9 Typescript (ii)

> **!** Important
>
> This page is ***not finished***, but might contain notes from the course developers. The curriculum, exercises, and recommended resources listed on this page is subject to change.

9.1 Curriculum

9.2 Exercises

9.3 Recommended resources

10 Typescript (iii)

> **!** Important
>
> This page is ***not finished***, but might contain notes from the course developers. The curriculum, exercises, and recommended resources listed on this page is subject to change.

10.1 Curriculum

10.2 Exercises

10.3 Recommended resources

11 Typescript (iv)

> **!** Important
>
> This page is ***not finished***, but might contain notes from the course developers. The curriculum, exercises, and recommended resources listed on this page is subject to change.

11.1 Curriculum

11.2 Exercises

11.3 Recommended resources

12 TypeScript in Excel

> **!** Important
>
> This page is ***not finished***, but might contain notes from the course developers. The curriculum, exercises, and recommended resources listed on this page is subject to change.

12.1 Curriculum

12.2 Exercises

12.3 Solutions to exercises

12.4 Recommended resources