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cheat sheets

This section will contain various cheat sheets which are helpful.

keyboard shortcut reference

This will contain a table that gives the equivalent commands for different keyboard shortcuts. It does not intend to be exhaustive but instead to hit all the major ones.

shortcut	Range function
Range related	

shortcut	Range function
SHIFT + Space	<code>EntireRow</code>
CTRL + Space	<code>EntireColumn</code>
CTRL + A	<code>CurrentRegion</code>
CTRL + /	<code>CurrentArray</code>
Arrows	<code>Offset()</code>
SHIFT + Arrow	<code>Resize()</code>
CTRL + Arrow	<code>End()</code>
CTRL + Plus (+)	<code>Insert()</code>
CTRL + SHIFT + L	<code>AutoFilter()</code>
ALT + SEMICOLON	<code>SpecialCells(xlCellTypeVisible)</code>
Application related	
F9	Calculate
CTRL + ALT + F9	CalculateFull -or- CalculateFullRebuild

TODO: finish this table

VBA Cheat Sheet

This will include a cheat sheet of common VBA functions, control structures and commands on common objects.

TODO: create this cheat sheet

Excel Object Model Cheat Sheet

This cheat sheet will provide a quick glance at the most commonly used objects in Excel and how they are related. It is meant to be a useful check when you know what you want to work with but are not certain how best to get there.

TODO: finish this list

-
- Application
 - Workbooks -> Workbook
 - Worksheets -> Worksheet
 - Range -> Range
 - * Formula
 - * Value
 - * Address
 - * [formatting things]
 - * Cells / Rows / Columns
 - Cells -> Range
 - ChartObjects -> ChartObject
 - * Chart
 - Series
 - Axes -> Axis
 - ChartArea
 - PlotArea
 - Shapes -> Shape
 - Names -> Name
 - RefersToRange -> Range

overview of 0 intro, overview

Not sure what to put in the introduction. Think about the goals of this book, its organization, resources on the web, etc.

comments on knowing Excel before starting VBA

The Basics of Excel chapter may not actually be needed. The problem with working through VBA is that it requires a baseline understanding of how to use Excel. In general, it requires more than a baseline understanding of how to use Excel – it requires an advanced understanding of how Excel works. In particular, it's important to know what happens by default when you do something in Excel. This then makes it much easier to reason through how the VBA is going to function.

TODO: add explanations for other reasons why: using formulas, intuition, knowing what's possible.

An example: if you have never used the keyboard shortcut CTRL+arrow to jump around a block of data, you would never think to look for the Range.End() command which replicates this behavior. Instead, you might be tempted to iterate through every cell calling Offset(1) until the cell is empty.

A second example: most people are familiar with the AutoFill behavior by dragging the corner of the current cell. This is great most of the time but has the bad habit of trying to predict a series when you just want a constant. There is also the Fill command (and a keyboard shortcut CTRL+D for fill down and CTRL+R for right) that will copy the formula or the value without trying to predict the next value. Fill is much more useful when working with VBA since it's unlikely to secretly ruin your data.

Knowing that there are multiple ways to do something and knowing the quirks of specific commands is invaluable when working with Excel through VBA. You will have a much better intuition for what will happen if you know how Excel normally does things.

If you don't have this intuition, you can still learn VBA and be effective, but you may find yourself falling back on common programming techniques that are not "idiomatic" Excel.

This section might include some the VBA equivalent of common Excel techniques?

TODO: decide if this section is needed

overview of 0.5 basics of VBA

section on VBA topics should include:

- basics of variables
 - common variable types
 - difference between value and reference types
- basics of control structure
 - if
 - select case
 - for loop
 - foreach loop
 - do/while loops
 - goto
- error handling
- Subs and Functions

most of this section is going to be boilerplate explanation of these things

consider how to improve on that to avoid saying the same stuff as everyone else (or just power through it to get it on paper)

later on, there should be an advanced VBA section to handle:

- classes
- events
- adding references to other objects (specifically Office and Microsoft Runtime)

The pitfalls of running macros and how they destroy the undo functionality.

- using the debugger
- using the Immediate window

VBA 101

This section will focus on the basics of opening the Visual Basic Editor and actually getting started with VBA. This is called VBA 101 because these are the steps that you have to know before you can start programming. Hopefully these steps are already done or you can work through them quickly.

There are a handful of ways of getting the VBE to open. Those include:

- Use the keyboard shortcut ALT + F11
- Use the button on the Developer tab of the Ribbon (if enabled) (TODO: include steps for how to enable this menu if needed)
- Hit the Debug button if an existing code sample fails
- Hit the edit button on the run macro button, again off the developer tab (also available with **SHIFT + F11**)

Of these, the first two are the more common ways to get the VBE to open.

Several of these methods require the Developer tab to be showing. In general, if you are working with VBA, this tab is useful. To enable it, you need to go through the settings to Customize the Ribbon. On a default install, this tab will not be visible.

TODO: add some steps and images for the Developer tab on the Ribbon

Once you have the VBE open, you can then begin to add or edit code for your spreadsheets. The basics of the simple program are included below.

TODO: add the steps for a Hello World... how to create Sub and output the text TODO: add pictures for these steps too

This section of the book is one of the few where the steps will be so clearly specified. I am going to this level of detail to ensure that you are able to get things started. This book will not include such detailed steps later for how to type and run code.

introduction to VBA

This chapter will focus on the basics of VBA that are essential to using VBA to work with Excel. The upside of VBA is that it has a very simple instruction set. The downside of VBA is that it has a very simple instruction set. Fortunately, the vast majority of Excel/VBA interaction can be handled with very simple instructions. Honestly, the real difficulty with using Excel/VBA is not the VBA side of things, it's managing the object model for Excel. This object model does not introduce new commands, but it does add a large number of interrelated objects, properties, and Functions that need to be known at some level to do anything. If you compare the length of this chapter to the length of the book, you will get a sense of what is meant by this.

An important thing to remember about VBA is that it exists outside of Excel, in some sense. VBA (Visual Basic for Applications) is derived from VB6 which is a legitimate programming language that (previously) was used for serious programming. These days (ca. 2017), no one starts a new project looking to use VB6; it just doesn't offer the features of modern programming languages. That VBA exists outside of Excel means that there are certain parts of the language that are independent of anything Excel has to offer. These aspects of VBA are the core parts of the language, and, simply, you have to understand these core parts before you can do anything related to Excel. Technically, you can get by copying code from the internet (or this book) and making simple changes, but you will never truly get good at VBA doing that. Also, doing that for more than a couple tasks is counter productive since learning VBA proper does not involve that many commands.

Having said all of that, VBA consists of several key instructions:

- Declaring and setting variables
- Declaring and calling Subs and Functions
- Logic structures
- Loop structures
- Other control structures (Errors and Goto)

In addition to those aspects of using the language, there are a handful of details related to programming in general that are worth hitting:

-
- VBA 101, opening the VBE and getting started
 - Adding references (how and why)
 - Debugging code and using the tools provided

The flow of this chapter will hit on the VBA 101 question first. From there, we'll hit the language basics, and then touch on the 2 more advanced aspects of using VBA and Excel together.

Finally, it's worth noting that this basic overview misses a couple parts of VBA that might come up from time to time. They will be mentioned at the end of the chapter in passing, but this book is not a VBA reference. This book is designed to get you using VBA in a professional setting with confidence. Knowing every nook and cranny of the language is not critical for that goal.

declaring and setting variables

One of the core tasks when programming via VBA is working with variables. Variables encompass a couple of different topics which makes sense since they are one of two core areas of VBA alongside control structures. That is, your programming exists of two possible categories: variables and control structures. Variables are made of the variables that you will need to declare and set to make your program work while also including all of the various aspects of the Excel object model. The object model is made of a significant number of variables (e.g. cell value for each cell) and a handful of Subs and Functions. The variables that you declare and use will look very similar to the object that the Excel model is using. There are also a large number of variables that you will create which exist to guide your own control structure or to encompass the algorithms that you need to execute.

To fully work with variables, it helps to split the topic into two areas: declaring variables and setting variables. These two topics are quite simple when it comes time to type out the commands, but variable declaration and setting is at the core of planning how a program will work. The variable declaration will directly shape how the control structures will work. The two go hand in hand and are equally important.

Declaring Variables

Declaring variables is a straight forward task. VBA offers a simple command to declare a new variable: `Dim`. Note that you can technically use a variable before declaring it, but you should really avoid this practice. It leads to the potential to create all sorts of bugs later. Just don't do it. To better avoid this, setting the flag in the settings (TODO: add a picture of that).

When declaring a variable, there are two components to it: variable name and variable type. Variable name is wholly your decision with only a couple of constraints. You are not allowed to duplicate the name of an internal command, and you should go to some length to avoid using the same name as an Excel object model name. Beware that naming a variable has certain conventions, but these do not have any effect on the program execution. The main concern with names is that they will directly affect your ability to work with and maintain your code. Naming things is hard. Pick a strategy that works for you and your coworkers and get on with it. There is no single answer here about how to name things.

The second part of the puzzle is to declare the type of the variable. This is THE core part of variables. When declaring a variable, you are essentially deciding if the type should be the generic `Variant` or if you should actually declare a type. Note that there are times when you have to use `Variant`, but in general, you should use the most specific type that is possible. These types can either draw from VBA or from the Object Model, or from your own created types. When thinking of variable types, there are two major groups of types:

- Value types = a number, string, or boolean
- Reference types = objects

Setting variables

Setting a variable is quite straight forward. The rule is: for reference types, you must use `Set`, for value types, you must not.

The real task then is to determine whether or not you are working with a reference type. The rule here is: if you are working with an object, it is a reference type. If you are working with a value (number, string, bool), then you are working with a value. Another approach, if you intend to use a `.` to call out some property of your variable, then it is a reference type and requires `Set`. The one odd exception here is arrays: they are declared without using `Set`.

Using Variables

It seems somewhat obvious that you would want to use a variable after declaring and setting it. This is generally always the case (why else would you create the variable). To that end, there are a pair of ways to use variables depending on whether it is a reference or value type. The easier one to understand is the value type where you simply use the variable as is the same as would appear in a mathematical expression. The more complicated example comes with reference types where the variable stores a reference to another object. These variables have the ability to access either a property of the type or the default `Value` of

the type. This distinction and the overall distinction between reference and value can become incredibly confusing with the Excel Object Model since so many properties of objects reduce to value types. An example is the value of a `Range` which will hold some number or string or Error depending on what the cell contains.

When accessing a property of the object, you will use the `.` and find the property by name. In this way, you can chain together a series of commands to access the properties of objects. It is oftentimes the case that the property is itself another object which makes it possible to use another `.` to keep going. If you are using the VBE and properly declaring your variables, the VBE will work to provide helpful suggestions of what may be possible to use next (this is called Intellisense). The one pitfall to Intellisense is when the return from a given property can be Variant or a combination of possible results. When this happens, Intellisense will not offer any suggestions and you are left guessing whether or not the command exists. This is where it can be quite helpful to do one of two things:

- Create a new variable with the type that you know the object will have and Set that reference before using it. This “cheats” and tells Intellisense exactly what you expect to exist.
- Read through the documentation and gain an understanding of what types are possible and just use them. There is no rule that the type must be suggested by Intellisense for it to be valid.

In general, I take a combination of those two approaches often. If I expect to use the variable a number of times, I will go with the new variable route to avoid guessing properties later. If I only need the variable once or am copying code from somewhere else (and know it works), I will just go with the code as is without Intellisense. The one upside of creating new variables is that it forces you to be more explicit with your declarations. It also clearly shows your intent to other developers that may see your code later. Finally, there is nothing worse than missing a typo that Intellisense didn't catch and having that be a show stopping bug at some point.

I mentioned it above, but it is worth digging into the default `Value` property a little more. This can be a source of confusion because very often, you will accidentally use the name of a variable without calling for a property. In other programming languages, this will result in a compile time or runtime error that is thrown because of the bad call. In VBA, your code will run and even worse will return something from the object that may not be what you want. When this happens, it can be incredibly difficult to track down the source of the error. To avoid this, you could never use the variable name as a shortcut of the `.Value` property. In practice this is a pain to manage and I will often mix and match whether or not Value is called. Sometimes, I am tired of typing out Value and just let the default work. Other times, I am being very diligent about calling everything explicitly to avoid some unforeseen error later. You will find that this comes down to your own preference and the preferences of others working on your code.

using Subs and Functions

The basic building blocks of your VBA efforts will be the Sub and the Function. It's possible that they are your only top level components if you do not use Class Modules. In all my years of using VBA, I've used Class modules only a couple of times, so they're not common.

Having said that, Subs and Functions are actually far more similar than different. The only real difference between the two is that Function can return a result back to the caller. A Sub on the other hand is meant to execute without returning anything back to the caller. It's possible to have a Sub manipulate a variable with can approximate returning a value for a little more work. If you're using a Function as a UDF (see chapter XXX, TODO: add link), then there are further limitations on what your Function can do. If you are not using it as a UDF, then there are no limitations that make a Sub distinct from a Function. The only difference is how you call them (if you want the return value) and that a Function is made to return something.

If you have a Function that does not actually return a value, it is the same as a Sub with the same code.

TODO: add an example of a Sub

TODO: add an example of a Function

declaring the parameters (Subs and Functions)

When creating a new Sub or Function you are able to determine the inputs to your new creation. There are a handful of ways of handling the inputs:

- Put the inputs into the parameters of the Sub/Function and allow the caller to provide them
- Use knowledge of the spreadsheet to determine the inputs (or prompt the user for an input)

The main split here is: do you require the person typing the VBA to give you the inputs? Or, do you use some other approach like asking the user or just pulling the inputs from the spreadsheet.

The most common approach is to pull the inputs out of the spreadsheet. This seems counterintuitive, but if you consider that the vast majority of VBA code is purpsoes wirtten for a single use, then it stands to reason that code will not be built on a large nujmber of Subs/Funciojns accepting parameters. The reason for this is that generally someone writes VBA to handle *their* spreadhseet and so the VBA just refelcts that spreadsheet. This works great for indivudal cases but can become a burden when building larger workflows. The main thign to consider for lager workflows is that as the complexity grows, tehre will be a large amount og code that is called multiple times or could be called separately from the main workflow. When thi sis the case, you are often served by pulling that code out into its own Sub/Funciojn wiiht aparameters.

To create a Sub or Function with parameters, you simply add them to the definition line:

```
1 Sub WithSomeName(firstParameter as String)
2
3 End Sub
```

This approach is very simple. You give the parameter a name and a type declaration. This is very nice because it nearly exactly matches the `Dim` statement with a Sub. That correspondence makes it very easy to start with an internally declared variable and then upgrade it to parameter. You can also go the other way: take a parameter and inline it into the Sub with some default or determined value. This is less common.

Once the parameter has been given a name and a type, you can simply use it within the Sub like any other variable. In this regard, your code will look the exact same. If you are the person typing the VBA to use this Sub, then you will have to provide an appropriate variable as the parameter to make it all work.

declaring an Optional parameter

The one additional thing to consider is that of `Optional` parameters. An optional parameter is one who is not strictly required. In lieu of a value, you can either leave the parameter missing or provide a default value. In either case, you can use the VBA specific function `IsMissing()` to determine if the parameter was entered. An Optional parameter can be a very nice feature when you are trying to determine whether or not to make a Sub take parameters or just use defaults. You can provide the defaults in the parameter declaration and then allow the user (person typing the VBA) to override them if needed. This is a very common approach when writing library type code; provide sensible defaults that can be overwritten.

calling a Sub or Function

When you are calling a Sub or Function, there are a couple of ways to do it. The preferred approach is to simply type the name of the Sub/Function along with any required parameters. This will call the Sub. Another approach is to use `Call SubName` which is the same as `SubName`. This is an older approach that some people prefer. It can sometimes be the case that Sub names are not particularly clear in the VBA and using `Call` has the effect of making it obvious that code flow is being directed into a Sub.

When calling a Function, you have the same approaches available. You can just use the Function name or use `call` (TODO: is that right?).

One thing to be aware of with Functions is how to properly handle the return from the function (assuming it actually returns something). This is where VBA gets a bit weird. The rules here split on whether the Function returns an Object or Value type.

For either type, you are required to call the Function with parentheses. This signals to VBA: please retain and use the return of this Function. For a reference type, you will need to use `Set` as required. For a value type, you will omit `Set`. See the code example below.

If you ever get the compile time error `Object reference not set` this means that you have not used a `Set` somewhere that is required. A good place to check are spots where you are using the return from a function. The same thing happens if you omit the parentheses. (TODO: is this right?)

```
1 Sub ExampleOfCallingCode()  
2     Dim rngReference as Range  
3     Set rngReference = someFunctionThatReturnsARange()  
4  
5     Dim dblValue as Double  
6     dblValue = someFunctionThatReturnsADouble()  
7  
8 End Sub
```

declaring the return type (Function only)

For a Function, the only extra step is to declare the return type of the Function. This is done after the normal parameters, with an extra `as Type` where `Type` is the actual type that you want to return. Note that this type must be compatible with all possible Types that you could return. Sometimes this means that you need to return a Variant in order to have all possible return Types available to you. There are times where this makes sense (and a large part of the Excel object model does this), but note that using Variant will make it hard to use Intellisense to figure out what your VBA is capable of doing.

TODO: is this a Variant by default?

TODO: give some examples of Function returns (or link to examples of them)

returning from a Function

If you want to take advantage of a Function, you need to return a value from your Function. This returned value can then be consumed by the caller (or not). To return a value from a Function, you simply use the

Function name as a variable and set its value appropriate. If the return type is an object or reference type, then you need to use Set to return the object. If it is a value type instead, you can simply set the return with an equal statement like any other value type. Once you have made the return statement, you can call Exit Function to break out of the Function.

For the caller, there are two things to keep in mind when using Functions. The first is that you must call the Function with parentheses in order to access the return value. The corollary of this is that if you call a Function with parentheses, you must use that return value to set the value of a variable. You will get an error if you do not do this correctly. Note that if you do not want the return value for some reason, you can avoid using parentheses in the same way you call a Sub. The second part is that you must call Set if the variable is an object/reference and not a value.

TODO: give an example of the return type and returning

logic structures

The logic structures are the backbone of nearly all VBA programs. There are a handful of times where you can just run through some commands with no branching logic, but in general, your program will need to make decisions based on some condition that it encounters. In order to make those decisions, you use the logic structures of VBA. There is really only a single logic structure in VBA, the If-Then structure, but VBA provides a handful of useful additions to the basic If-Then to make programming a little easier.

The main logic structures then are:

- If-Then
- If-Elseif-Then
- Select-Case

The If-Then is the main building block that allows you to do something if a condition is true or do something else otherwise. The If-Elseif-Then allows you to add additional conditions to check before defaulting to the Else. If any of the Elseif statements evaluate True, then the branch will stop traversing the conditions. The Select-Case is an extension of the If-Elseif-Then that always compares a given variable against different possible values.

TODO: add example of the different forms of If-Then

For logic evaluation, there are always a handful of ways to arrive at the same result. You are allowed to evaluate multiple conditions in a single If-Then statement by using And and Or. You can also “nest” different logic blocks inside of each other to create the same sort of logic. In this way, you can either

use If-Elseif-Then or you can do an If-Then and stick a second If-Then in the Else clause. These will be equivalent. Sometimes one version looks better or makes more sense than the other.

helpful logic functions

TODO: add an overview of the functions And/Or (is there a XOR?) along with the logic operators <,>,<=>, = etc.

the Select Case

The Select Case makes it possible to compare the value of a variable against multiple values without having to type the variable name every time. This is a purely syntactic feature that makes programming easier in certain cases. You can completely duplicate a Select-Case with an If-Elseif-Then, but you may have to type more code.

TODO: add an example of a Select Case

Note that this section is fairly short. Logic structures are so prevalent in normal VBA code that should look for examples of these in the respective chapters instead of this section.

loop structures

The loop structures are an integral part of VBA programming. You are pretty much guaranteed to use them immediately. In some cases, you are more likely to use loops than logic structures. The reason that loops are so critical is that they allow you to perform an action multiple times or across multiple objects. Given the nature of a spreadsheet (where you have a high multitude of cells) and the reasons for using VBA (you want to perform some action multiple times) you really can't avoid loops. Gaining an understanding and comfort with loops is critical to your skill with VBA.

There are several types of loops that work similarly but have different use cases. Those include:

- For Each - useful when you have a collection and want to do something for each object in that collection (this is the most common loop to use since you will nearly always have a collection of Ranges or some other object to iterate through)
- For - useful when you want to do something a specific number of times
- Do/While - run a loop until a condition is met which is useful when you do not know in advance how many times to run the loop and you don't have a finite collection

It is worth noting that all loops can be written as a Do/While loop, but you will nearly never do this. There are good reasons that the For Each and For loops exist.

It is also worth mentioning here that I typically try to avoid For loops whenever possible. I always prefer to use a For Each loop if it is appropriate for the application. This is not an approach that I used from the beginning but have begun to value the use of For Each loops. If you are coming from a programming language that does not value collection iteration, then you might avoid the For Each loop at first. I'd strongly recommend you learn to use the For Each and appreciate it. Your code will be much cleaner and easier to read with For Each loops instead of the alternatives. Especially when dealing with Ranges, it is tempting to iterate through them as a nested For loop. You should really avoid this.

TODO: add an example of a bad For loop

For Each loop

It is not traditional to start with the For Each instead of the For loop, but I personally use the For Each far more so I'll start there.

The For Each loop is used whenever you have an iterable collection. An iterable collection can come from either the Excel object model or your own code. In general, most of the Excel object model returns an iterable collection. This is especially true for Ranges.

TODO: add a list of iterable collections that can be used here

You are not required to put the variable name in the Next line. I recommend not including the variable unless you have tons of code in the loop and are nesting loops. Typically you will rename the variable and then get a compile time error because the variable names don't match. I've never found the variable name in the Next line to help much.

TODO: add an example of a For Each loop

For loop

Another style of loop that exists is the "bare" `For` loop. This is one of the simplest loops to understand and control. The idea is simple: iterate through a chunk of code a given number of times. The most common forms of the `For` loop work through a fixed number of iterations. One example is easy: if you want to output the numbers 1 through 10 into a column of cells, you can easily use a For loop to output the number. This is a bad example though since it can easily be done with normal Excel functions, but it is quite common to

do the equivalent sort of task when writing a larger macro. In that sense, it is easy to forget how versatile the For loop can be when needing to do something some number of times.

Compared to a While loop (discussed below) there are a number of advantages to the For loop:

- Much easier to control the “exit” strategy and avoid infinite loops
- Can be wired up with constants that are intuitive and just work
- Can be extended to use variables instead of constants to provide more flexibility

When moving beyond the simple 1 to 10 For loop, there are a handful of options which can be pushed into ever complex strategies:

- Use a variable for either the starting index, increment, or end point
- Use a negative step to go backwards through a list of numbers
- Use `Exit For` statements to control execution and kick out of the loop

On that last point is where you will see VBA is woefully underpowered compared to “modern” programming languages. VBA does not provide a simple command to `continue` a loop. There is a `Exit For` which can be used to kick out of the loop, but to `continue` you must create a `:LABEL` and use a `Goto LABEL` statement to jump there. There is nothing necessarily wrong with this, but it is an approach that is annoying and prone to some mistakes. The biggest issue is accidentally moving the label or having some other position issue. The annoyance is having to create a label and use a `Goto`. There is nothing inherently wrong with a `Goto` but they provide create power which means awful bugs later.

It is worth noting that the `For Each` loop is a simplification of a `For` loop for a number of instances. In most cases, you could create an index and then iterate through an object by index, storing a reference to the object being stored. Behind the scenes, I believe this is how the majority of internal commands are handled. Despite the 1:1 translation between the two loops, it is typically MUCH simpler to use a `For Each` loop if you just need access to the underlying object in the collection. I will nearly always create an index outside of the loop and use it alongside a `For Each` instead of creating a `For` loop and storing a reference to an object. It always seems vastly simpler to store an Integer than an object. Aside from the marginal advantage of not calling `Set`, there is an immediate payoff of a `For Each` loop that if you name the variables correctly, you can typically read exactly what the code will do. This pays dividends for yourself and others later when reviewing the code.

It is also worth mentioning that there are a handful of instances where you are typically required to use a For loop even if you want to use the object being used. The standard example here is if you will be modifying the collection that you are iterating. In this case, you will rapidly create iteration issues trying to modify the collection inside the loop using it. In some of those cases, you will get runtime errors, but in others

you will just get unintended consequences. The most common example of doing this is when you want to delete items from a collection while iterating through it. Let's say you need to check whether an item meets some criteria before deleting it. There are two ways to handle this:

- Use a For loop and run through the collection BACKWARDS. The direction is critical because it means that at worst, you are working at the end of the list which will not affect future operations.
- Use a "dual loop" approach.

An example of item 1 is shown below.

TODO: add example of backward loop

The dual loop approach is worth mentioning further since sometimes it can give you an elegant way out of a bind. The idea is that instead of modifying the collection while you iterate it, you store some amount of information outside of the collection and then use that to determine what to delete. This typically only works if the items being deleted exist independently of the collection that holds them. This happens often enough with Excel that it is worth giving a concrete example: deleting Rows from a Worksheet. To handle this dual loop approach, there are two possible options:

- Use one loop to create a collection that stores the rows to be deleted and then iterate that collection in a new loop
- Build a larger Range to delete as you go and then use an Excel function to handle the actual deletion

The latter option is only technically a "dual" loop. Technically Excel will use some sort of internal loop to actually delete the Range. You are only required to cleverly create the Range which allows this internal process to be kicked off.

TODO: add an example of the Collection approach for deleting Ranges

TODO: add an example of the UNION-DELETE approach for deleting ranges.

TODO: add some examples of For loops and how they might be used

Do/While loop

The final style of loop is the Do/While loop. Although it is mentioned last, it is ultimately the simplest type of loop that exists. The idea is: run until some condition is meeting. This loop matches very nicely when your looping strategy involves some condition. You simply put the condition into the loop and let it work. The downside to a Do/while loop comes down to the possibility of an infinite loop. This leads to the common problem of a macro that hangs Excel and requires intervention to shut down. Infinite loops are

technically easy to avoid, but it is far more common in practice to skip the steps that help avoid infinite loops.

It is worth mentioning at this point that all of the loop varieties can be recreated from the other loop varieties. From this standpoint, there are slight advantages to one style over another, but at the end of the day, you simply write the loop that works for the task at hand.

For a Do/While loop, there are two possible ways of writing it. You can either do a `Do...While` or a `While...Loop`. The main difference is whether or not the loop will execute before the condition is checked. There are instances where one style makes more sense over the other. Typically you can always use the `While...Loop` variety, but you may be required to type an initialization statement before the loop that is repeated within the loop.

Some common examples where a While loop make sense include:

- Iterate down through a column of cells until some condition is met (typically a blank or non-blank cell). This is quite helpful when it is difficult to create the `Range` that might be used for a `For Each` loop.
- Iterate through the file system using the `Dir` command to find files to open and process

The While loop tends to make the most sense when you are not iterating through a fixed collection of objects because the `For Each` does a better job there. You also would avoid using it when you have a fixed number of iterations to run where a `For` loop makes a lot more sense. That then leaves the instances where you want to loop through some action some number of times, but you're not sure how many times until you start going.

If you are particularly adventurous, you can make use of the `Exit Do` command to exit out of the loop mid iteration. This pairs nicely with a `While True` at the start of the loop to ensure that nothing else will kick you out of the loop. There are instances where this can be a simple way to loop, but you have to be absolutely certain your `Exit Do` command will be triggered at some point or else you guarantee an infinite loop.

TODO: add an example of looping use `Dir`

TODO: add an example of a loop that works through a range using `Offset`

which loop and why

There are a handful of common reasons you might go for one loop instead of another. Worth knowing is that in general you can use any of the loops and get the same result. One approach is typically much easier

to program, understand, and maintain.

A couple of good things to remember:

If you are going to modify a collection in the course of iterating through it, you should not use a For Each loop. The For Each does not update the iterable collection if you modify it during a loop. This is particularly important if you are looping through a collection to identify items to delete from the collection. You should never do this in a For Each loop. When deleting, you should typically use a For loop and iterate through the collection in reverse order. This makes it easy to handle deleting items since you cannot get out of order. You can achieve the same result with a Do/While, but I won't cover that.

TODO: add an example of deleting via a For loop

If you need an index/incrementing variable alongside your loop, you are not required to use a For loop. You can always create a new variable and increment it yourself inside the loop. This is sometimes preferable to switching to a For loop solely to get the counter/index variable.

If you are using a Do/While loop, you should give serious consideration to adding a counter and breaking the loop if the counter gets too large. It happens far too often where I use a While loop and end up freezing Excel because the loop never terminates. You can sometimes break the code and get Excel to respond, but that does not always work. This is especially important if you are generating code that others will use since they may be less familiar with how to break out of an infinite loop.

You may need to break out of a loop. Unfortunately, VBA does not have the normal Break and Continue commands that you might be familiar with from another language. The only way to break out of a loop on the spot is to add a label use a Goto command unless you are able to break out of the Function/Sub completely using Exit. This always feels dirty to me so instead I will typically structure the loop with a Boolean that can detect whether the next iteration should continue. This works for Continue, but it is not a good solution for getting a Break. The only way to do this is via a Goto. Just do it.

other control structures

With command

The **With** command allows you to place a given variable within "scope" and avoid repeatedly typing that variable's name for each required call. The **With** command exists solely to reduce the number of times that a given object or variable name is typed. You are never required to use a With command to accomplish a goal, but it can be helpful to clarify or avoid having too long of a code block. Having said that, a With block can be incredibly confusing to read especially when mixed with the always in scope function calls

like [Range](#) or [Cells](#). It is incredibly easy to avoid typing the required `.` to start a new line and accidentally refer to the globally scope object instead of your `With` scoped object. For this reason, I very rarely use the `With` command. When I do use it, I will typically only use it when I am workign with a nested object that might be several levles deep. Having said that, I mostly avoid the `With` block by creating a variable which holds the object in question adn using that instead. I have found that parsing a `With` block later can quickly become a confusing mess becuase of the difficulty of spotting the `.` which is critical.

If you read through some of the most common questons on teh interent about “why my VBA no work?” you will quickly find issues with `With` blocks accidentally calling a globally scoped command. I have never asked those questions on the internet, but I have definitely been bittne by teh same errors where a `.` is missed and the commang goes bonkers. It happens but is easily avoided by not using [With](#).

GoTo staements

[GoTo](#) statements are used ot force execution to jump to a speciifc Label regardless of anythign else that the progrma is doing. A [GoTo](#) statement is requiried for error handling but is otherwise frowned upon by programmers with expereince in other languages. The rpoblem is that a bad [GoTo](#) statement allows you to do much damage within a program because you can quickly corrupt your program state by jumping around. Also, other programming languages tend to include all fo the nice features that have replaced places where [GoTo](#) was previously required. A good example of this is breaking out of a loop or skipping ot the next item in a loop. The latter is tpyically handled with a [continue](#) statement in other langugaes. In VBA, this statemnet does not exist and you are reuquired to use a [GoTo](#) if you want the functionality.

To make a `GoTo` statement work, you need ot have a Label that the `GoTo` points to. An example looks like this:

```
1 Sub GoToExample()  
2     'doing some stuff  
3  
4     If someConditiojn Then  
5         GoTo EndOfCode  
6     Else  
7         ' do some other sutfff  
8     End if  
9  
10 EndOfCode:  
11  
12 End Sub
```

The rule for labels is that they are required to occur at the front of the line (no indenting), they must be a single variable name without spaces, and they must end with a colon.

You should go to reasonable lengths to avoid using GoTo statements for anything other than error handling. They are the root of a lot of problems as execution order is concerned.

Error Handling

One final control structure that exists is related to error handling. It is an inevitable consequence that computer programs will eventually throw errors. There are a lot of techniques and good practice that can avoid errors, but sometimes you will be forced to deal with an error. The alternative to error handling is usually a pop up that informs the user that something went wrong. For an experienced user, they may be able to handle the `Debug` or `Continue` or `End` decision, but your typical user will assume that your code has failed catastrophically. It's entirely possible that the error has no effect on your intended outcome, or that the error could be resolved if the user just hit `Continue` but the take home message is that *if* something *has* to happen to respond to an error (or a possibly error), then you need error handling.

The elements of error handling are simple:

- Determine when to allow an error to be thrown
- Determine what happens with execution when an error occurs
- Determine where to go back to once the error state has been addressed

The first decision to make is whether or not to allow errors to interrupt execution. By default, the answer here is “yes”, an error will interrupt execution. If you want to handle this differently or reset it back to default, there are a pair of commands that can be used:

- `On Error Resume Next`, ignore all future errors, just keep trucking
- `On Error Goto 0`, stop execution immediately at the next error

If you are savvy about searching online for solutions to your problem, you will often see option 1 listed as the “go to” (or is it `GoTo`, ha!) solution for getting around an error. In the technical sense, yes, `On Error Resume Next` will absolutely get you around an error. It will by definition ignore the error and just keep going with execution. For the vast majority of workflows, this is an awful approach. Very often an error is indicating that something has gone awry from your expectations. If those expectations were reasonable, then it is very likely that future code will not work as intended. Therefore, if you are getting an error, you

should give serious consideration to finding the source of it before you [Resume](#) [Next](#) through it. Ignoring an error that should have been addressed nearly always causes more pain later.

The other harsh approach to respond to an error is to force execution to stop immediately. This prompts the user with the popup about how to proceed. This prompt is helpful because it gives two options that may allow you to solve the problem. The first is [Continue](#) which will attempt to run the line of code again that caused the issue. If the error still persists, then you will simply get it again. No harm. However, it is also possible to change the state of Excel while the prompt is visible. This means that if your code was relying on an [ActiveChart](#) and you did not select one; you will be able to select a chart before hitting [Continue](#). This can be a quick way out of a problem if you are confident where the error occurred. If you are programming only for yourself, this can also be a clean way around dealing with waiting for user input using another [GoTo](#) approach down below. Having said that, allowing a user to deal with an error prompt is absolutely awful in terms of usability.

The second way you can deal with these error prompts is by hitting [Debug](#). This is likely the first response when an error occurs because you are very unlikely to know where the exact error occurs. Once you've seen it however, then you may be able to continue above. The nice thing about debugging the error is that you get some powerful tools to try and solve the problem. For a full overview of debugging, check out the other section (TODO: add link). The specific features that are nice for dealing with error include:

- Locals window, which will provide an overview of all the local variables and their current state
- Set next statement, which will allow you to skip over an error or rerun a line of code whose state may have changed between executions
- Immediate window, which will allow you to either run arbitrary commands or possibly output information about the program state.

All of those tools combined should make it possible for you to determine the source of an error. Once you have determined the source of an error, you can then set about resolving the error, again using the debug tools. Once you have solved the problem, you should give serious consideration to then adding that solution to the code using proper error handling techniques. Again, it is absolutely awful to present the user with an error dialog and expect them to be able to figure it out. Even if you are the user, you will absolutely tire of dealing with error prompts that can be handled with proper handling.

If you want to address an error, there are a couple of ways to handle that. They all rely on using the [On Error Goto LABEL](#) technique. This allows the code execution to jump to a specific place in your code. That area in your code is then able to do a couple of helpful things:

- Query the state of the [Err](#) object
- Attempt to address the error and then kick code back to the previous spot

-
- Provide the user with proper feedback before killing execution
 - Log the issue accordingly before failing or prompting the user

With all of these approaches, the idea is simple: redirect execution to a known spot when the error has occurred. Once you are in a known spot, you can then step through possible problems and possible solutions. If you want, you are then able to send execution back to another spot to advance. If you cannot resolve the error (or determine what caused it), you can then end execution all the same. Ideally you end execution with a better message than the normal prompt.

TODO: give an example of some error handling code

avoiding errors Although this section is about error handling, the best error handling is an approach that makes it very difficult for an error to occur in the first place. As you call into specific VBA and Excel Subs, you will gain a feel for which ones can cause problems. On the VBA side, there are a number of specific calls that will lead to errors:

- Indexing into an array with a index that is not valid: `Sheets("SomeSheetThatIsMissing")`
- Attempting to use a property on an object that does not exist
- Sending invalid parameters to a function

All of those items above have the nice property that you may be able to provide checks for when you will enter an error state. The upside of this approach is that you can use an `If . . . Then` statement to check for an error causing state and then step around it. Before using `Range.Value`, you can check that `If Not Range Is Nothing`. `Nothing` is the default value for a reference type before it has been set to a proper reference. You are always going to get an error if you attempt to use a `Nothing`. You can avoid a ton of errors being thrown by simply checking for `Nothing` and avoiding its use when it appears.

For a lot of arrays and other iterable objects, you have different approaches for checking if something is a valid index before accessing it. For a `Dictionary`, there is the `Exists` method. For `Worksheets` and other Excel arrays, you are always able to iterate through all of the items to check for existing before then using the index. TODO: add example of iterating sheets. It is very rare for the performance of VBA to be affected by these types of checks. There are instances where it is not appropriate, but in general, these techniques work fine.

Application.XXX functions In some instances, it is possible to trade a runtime error for a return value that has a type of error. This occurs with the `Application.XXX` functions where XXX includes items in the list:

- Match

-
- TODO: any others?

This can be beneficial because when the function returns an error, you can then turn around and deal with it by checking `IsError`. If the function throws an error instead, you are forced to use proper error handling to catch the error and attempt to resume state.

common VBA errors TODO: add section about 1004

TODO: add information about compile time errors vs. run time errors.

common Excel errors In addition to the VBA errors, there are also a number of Excel specific errors that happen often enough that they should be addressed. Some of those common examples include:

- Using `ActiveXXX` without have `XXX` selected. This is most common with `ActiveChart` where it is possible to not have a Chart selected. This is not possible with `ActiveWorkbook` or `ActiveSheet` since one will always be active. TODO: what about `ActiveCell`?
- Using `Selection` when the “wrong” thing is selected. It is quite common to `Set` some variable equal to `Selection`. If the wrong thing is selected, you will get an error about `Type Mismatch`
- Attempting to make a selection when it is not valid per the UI. This is most often the case when you attempt to `Select` a cell when its Parent Worksheet is not selected.
- Attempting to build a Range across Worksheets using `Union`
- Attempting to iterate through a Range of cells by checking `Range.Value` if the Range can contain errors. If this is possible you will instead have to check for errors first.
- Attempting to access or change the `AutoFilter` if it has not been enabled first

There are also a ton of instances where some function returns `Nothing` and you do not check for it. This most commonly occurs with:

- `Range.Find` where nothing was found
- `Intersect` where the two Ranges do not overlap
- TODO: add some others?

As a final note, it is worth mentioning that the sign of a good programmer is one who has a feel for when errors can and cannot occur. You will begin to appreciate when it is needed to add error handling code versus when you know you will not need it. Too often as a beginner, you will be excluding error handling because you are unaware of what can go wrong. As you get better, you will start to exclude error handling because you actually know that no errors can occur. Until you get good, the result may look the same (no error handling code) but the result to the user is prompts and halted execution in one case.

where Excel and VBA meet

The previous sections focused on the aspects of VBA that exist independent on Excel. It is worth ending this chapter with a section that discusses the general theme of where VBA and Excel actually do intersect. The main thing to remember is that VBA provides the programming constructs and language, while Excel exposes an object model to VBA that can be programmed against.

A good rule of thumb is that anything you can do in Excel can be done via VBA. This is probably not an exaggeration. The Excel object model is incredibly detailed and provides access to every nook and cranny of an Excel spreadsheet. This gives you enormous power to manipulate a spreadsheet in whatever way you can imagine, but it also means that it is easy to be overwhelmed by sheer volume of commands and objects that exist. Fortunately, there are only a handful of common/useful objects to start with and within those objects there is a significant amount of overlap. For example, the Range and Chart both expose formatting related properties (e.g. Border colors) but the ways of editing those are the same on both objects.

TODO: is that true about the Borders being the same?

TODO: finish this section... not sure where it's going

adding references to external code

This section will cover how to add References to other files and programming components. There are 2 main reasons for why you would need to do this:

- You want to access some code from an Excel file that you or someone else created
- You want to access code from an existing component on your computer

The latter reason on the list is the more common reason for adding a Reference. There are a handful of common references that are added if you want additional components that are not available by default. Of these, the most common include the Microsoft Scripting Runtime and the references to other Office programs. For example, if you want to create a Dictionary, you will need to reference the Scripting Runtime. In general, there are a number of references that are nearly guaranteed to exist on all Windows computers. Having said that, there are also a handful of references that are commonly made where the required file may not be available. This uncertainty about the files available on a system is the major downside of using these references.

TODO: add a list with other common references and what they might include

For the first item, there are times where you have created some code that would be useful to use somewhere else but that you don't want to copy. This can be common for using helper code that you know is included

in another file. The major drawback to this approach is that you are creating a permanent link between the file and the reference. This means that the one file will quit working if the reference ever moves or becomes unavailable. Despite this drawback, there are times where this can be convenient and the drawbacks less significant.

To add a reference is relatively simple. You simply go to Tools -> References. You can then check the boxes for any references that you would like to add. To add a reference to an existing Excel file, you will have to browse to the file and select it that way.

TODO: add some images of how to add a component

debugging your VBA code

One of the most useful features of VBA and the VBE is the ability to debug your code simply and in place. It is easy to take for granted the power of the VBE debugger, but it is worth mentioning that it is a solid debugger. The debugger has a handful of specific uses related to debugging your code:

- Stepping through execution and watching the movement of values into and out of variables
- Using the Immediate Window to execute arbitrary code or output the results of some value
- Setting the next instruction to force VBA to jump to an arbitrary point in your code
- Viewing the call stack to see how you reached a given spot
- Breaking at an arbitrary breakpoint or after an error was thrown

entering the debugger

To enter the debugger, you need to either set a breakpoint, hit Step Into, hit the Break key, or have an error thrown that prompts for debugging. By default, you will not be using the debugger while your code is running. This is actually a good thing since debugging code adds a large overhead which will kill performance. The most common approaches to entering the debugger are to set a breakpoint or via an error. This lines up with the idea that you either want to debug a specific point in your code or that you want to be able to see what went wrong when an error is thrown.

When setting a breakpoint, there are a handful of reasons for choosing where to set one:

- Right before an important step so that you can see the before and after state
- Inside of a control structure so that you can see whether or not execution enters that structure. Sometimes there is information to be had when the code does *not* reach a breakpoint.

When breakpoints, you can technically disable them instead of removing them if you do not want them to trigger. I never use that feature.

If you are entering the debugger through an error, you simply hit **Debug** on the prompt. You will be starting on the line that threw the error ready to execute it again.

The other ways to enter the debugger are by hitting the CTRL+BREAK shortcut. If the VBA is at a stoppable point, this will cause an interrupt which gives the same prompt as the error prompt. From here, you can hit **Debug**.

The final approach is to use the Step Into button on the code to run. TODO: is this true?

stepping through code

Once you have entered the debugger, there are a handful of ways to affect execution. They are:

- Run
- Step Into
- Step Over

TODO: add a picture of the toolbar icons

TODO: explain how to reach these commands along with the shortcuts

Run will tell the debugger to just keep running until it hits another error or breakpoint. This is the same as normal execution.

Step Into and Step Over do the same thing with one difference. They both tell VBA to execute the current instruction and then resume debugging after it. The difference is how they handle whether or not to enter a **Sub** or **Function**. If you have written a Sub or Function of your own and then call it, you have two options while debugging. You can either enter that Sub and step through the commands in there. Or, you can treat that line with the Sub as a single step which can be processed as a single instruction. If you do that, you will **Step Over** all of the intermediate execution and resume debugging once code returns back to the level you started at. This is very important if you have a large number of nested Subs and Functions. The debugging steps allow you to decide how “deep” into the call stack you will go to pursue your debugging. Sometimes, you will know that a given Sub works as intended and you do not want to step into it. Other times, you will reach a Sub being called and want to know exactly how it arrived at its output.

If you want to step through to a specific spot but cannot get there easily with the commands above, you can always just set a new breakpoint right there and hit **Run**. This will run until that line. You can also right click on a line and do **Run until this point** and you will get the same effect. TODO: is that right?

viewing the state of your code

The whole point of debugging is generally to view the state of your code (or the Excel side of things) in process. The idea of viewing the state means a couple of concrete things:

- What are the values of specific variables?
- What was the order of execution? Which control structures were processed and in what way?
- What happens if I do “this” instead of “that”?

Each of those is hit below:

values of variables Typically, the most important aspect of debugging is seeing which variables hold which values. The idea is that if you can see what the variables hold at runtime, you can check that against your expectations and then gain insight into why your program is behaving the way it does. Other times, you want to see the values of things so that you can decide how to proceed from your current point. VBA provides a number of ways to check the value of a variable:

- Hover over the variable and allow the VBE to show you the value
- Using the Locals window
- Using the Immediate window with ? added to the start (TODO: is that the same as Debug.Print?)
- Using the Watch window after creating a watch
- Running a command where you put the value into the spreadsheet

The VBE is fairly helpful when debugging compared to other debuggers. It does about what you would expect. This means that you will get tooltips when you hover over variables. This works well for variables that hold a value and not an object. For an object, if you hover, you will get the `.Value` property of the object and not a drop down to explore. In this regard, the debugger is inferior to a modern Visual Studio instance.

If you want to explore the properties of an object, or see a persistent value without hovering, you can use the Locals or Watch window. They do the same thing: show the values of variables while also allowing you to click down into Objects and their properties. The Locals window works by giving you a list of all the local variables automatically. The Watch window works by requiring you to provide the variable name or command that you want to watch. I always start with the Locals window since typically local variables are what I want to see.

When reviewing the contents of an object, beware that VBA will not show you all of the properties of the object. In particular, it will not show you properties that are the result of a Function instead of a normal

property. For a lot of Excel Object Model objects this is a key point. There are a large number of properties that you will need to add to the Watch window or query directly with the Immediate window to see their value. A common example: `Range.Address`.

TODO: add an example of using the Watch window

To use the Immediate window, you first need to enable it via View (TODO: add this for others). Once enabled, you can use the Immediate window as a place to execute whatever code you want. It works by executing single lines at a time. If you want the output of a command, use `?` at the start to print the result. You can use the Immediate window whenever, including during normal development (i.e. even when code is not running).

TODO: add an example of using the Immediate window

One particular thing that can be done (although not often) is that you can use the spreadsheet as a place to dump the results of your debugging. Sometimes, you will need to inspect some object and find that the VBE is just not that helpful. Maybe you have an array whose values you want to check. The simple approach here is to dump that array to the spreadsheet using the Immediate window (or actual code) and then set a breakpoint to inspect it. This gives a nice back and forth between Excel and VBA that simply does not exist in other programming environments. Once you see Excel as a huge playground to dump arrays, you will find all sorts of using for that while programming.

forcing execution

In addition to watching the execution of a program, you also have the ability to change the execution. This is done by using the `Set next command` (TODO: name? while running). This is the “nuclear” option of debugging because it does exactly what it says. It will tell VBA to execute *whatever* line you want next. This allows you to completely ruin your execution while also providing you the power to step to a given spot. It’s always the case when writing code that you end up on the wrong side of an If/Else while developing a loop. Sometimes, you just want to see what happens if you go down the other branch. This option allows you to test that alternative execution path without having to modify your code. You just tell the debugger to execute that branch next and things will work. Very often however, you can use this feature to accidentally skip over code where variables are declared or Set and then you will have all sorts of errors because objects are set to `Nothing` instead of the values that are required.

Despite the pitfalls of moving execution arbitrarily, most people who know this feature exists are capable of using it appropriately. They typically are not surprised when things break.

viewing the call stack

One final feature which is useful is to check the Call Stack. The Call Stack is a list of all the proceduring Subs or Functiojns that are “active” preceding the current command. It gives you a list of all the places that came before your current line of code. The Call Stack is invaluable when you have started debuggin following an erorr because oftentimes you will nto know how you reached a given spot. This is epecially true if you are debugging code that is used in multiple places.

To see teh Call Stack do View->Call Stack. You can then double click on an item adn jump back to that spot. Note that the VBE will attempt to show you the vales of variables at that location whcih can be very helpful.

The Call Stack can be very helpful if you are using recursive code that calls itself. This code can be very hard to debug because oftentimes a breakpoint will trigger more than you want. IF you are waiting for an error on the 8th time through a FUNctiojn, then you don’t want to skip the breakpoint 7 times. Instead, you can wait for the error, then use teh Call Stack to step back through teh previosu iteratiojns adn see what happeneded.

TODO: add a picture of the call stack

summary of Selections

The selections chapter needs to focus on the ways to access Ranges from VBA. These should cover the various ways to mimic normal ways of selecting along with VBA special stuff.

ways to get a Range object

- calling `Range`
- calling `Cells`
- from an existing `Range` _ `Cells` _ `Rows` _ `Columns` _ `SpecialCells` _ `Offset` *Resize* *EntireRegion* _ `End`
- from a Name object
- using `Selection`
- using `ActiveCell`
- using `Union` and `Intersect`
- using `Find`
- using `UsedRange`
- using `Application.Index` (or is it only `WorksheetFunctions`?)

-
- using `CurrentArray`

some common patterns combining these techniques

- the Offset-Intersect approach (move a block down and intersect with the original)
- the Offset-Resize pattern when you move to a cell and expand the selection based on something
- the Union-Delete approach to getting a Range to delete

introduction to selections

Identifying and using a `Range` object in VBA is the most critical aspect of building usable macros and helpful code. This point can be missed since you always have access to `ActiveCell` or `Selection`, but you will quickly reach the limits of VBA if you only use those functions.

This chapter will focus on the myriad ways to access a `Range`. A `Range` represents any (and every) cell in a `Worksheet`. The power of the `Range` is that it can represent a single cell, a row, a column, all cells, or a discontinuous collection of any combination of those options. From the `Range` you can then have access to the core functions of Excel/VBA.

The motivation for finding a `Range` is simple: the cell is the core entity of a spreadsheet, and presumably you're using the spreadsheet for some reason. You can technically write VBA code that executes without ever touching the underlying spreadsheet – and this can be useful at times – but more likely, you are using Excel and VBA because your data or use case is in Excel. If you want to access and work with the data in an existing spreadsheet, you will do so using a `Range`. If you want to put new data into a spreadsheet, you will use a `Range` to do that. If you want to use the more advanced features of Excel (e.g. Charting, PivotTables, etc.) you will use a `Range` to tell Excel how to drive those features.

Simply put, you will not be writing useful and maintainable VBA code unless you've got a strong command of working with the `Range`. To that end, this chapter will describe the ways to get a `Range`.

When thinking of the `Range`, you should think in terms of strategies for navigating `Ranges` and the actual code to execute those strategies. In some cases, the strategy is as simple as using the right command, but, often, you are required to think a step or two in advance about how to get the `Range` you want based on the nature of the spreadsheet and the actual task to be completed. For example, you will handle a block of data that is largely blank cells (sparse) different than a fat chunk of data with no missing values (dense). For the latter, you can quickly navigate the block of data with `Range.End`; not true for the former.

When thinking of the different strategies, the major split is whether you are starting with a blank `Worksheet` or if you are working with data in an existing `Worksheet`. If the `Worksheet` is blank, the main task is managing the `Ranges` that you are creating to place data on the sheet. If the `Worksheet` contains data that needs to be processed, the goal is to identify the parts of the data you need and understand their relationship to other parts of the `Worksheet`. Often, you will be combining both of these workflow (i.e. process data into a new form) and will require both ways of thinking, possibly interleaved throughout the same code.

When the term `Selection` is used here, it refers generically to getting a `Range` reference. That `Range` could actually be `Selected`, but the goal is generally to avoid selecting cells. Instead, the reference is used directly to do some processing.

strategies and methods for selections, existing Worksheet

When working with data in an existing `Worksheet`, the main goal is to find the section of the data that you actually want to process. This task can range from trivial to the bulk of the VBA code. A rough overview, starting with trivial is:

- Use the selection – `Selection`
- Use the ActiveCell – `ActiveCell` (see later for why these are different)
- Hard-code the address of a single cell – `Range("A1")` or `Cells(1,1)` (please don't use the latter)
- Name a cell and use that name directly – `Range("CellName")`
- Iterate through all cells – `Cells`, `UsedRange`
- While iterating through cells, use some logic to identify if a `Range` is the one you want: _ Check the `Value` of the cell _ Check if the cell has some property (e.g. `HasFormula`, `HasArray`, etc.) * Check the `Style` of the cell
- Take an existing `Range`, possibly all cells, and pare it down using: _ Move from a known cell to a new spot – `Offset()`, `End()` _ Take a subset of an existing `Range` – `Cells`, `Rows`, `Columns`, `Areas` _ Take a an existing `Range` and change its size – `Resize()` _ Take a super set of an existing `Range` – `EntireColumn`, `EntireRow`, `CurrentRegion`, `CurrentArray` * Allow Excel to filter the `Range` based on things it tracks (e.g. value, blank, hidden, etc.) – `SpecialCells()`
- Identify several `Ranges` and combine them – `Union()`
- Identify several `Ranges` and use only the common cells – `Intersect()`
- Pull the `Range` reference from some other object
- Name a cell and use that name indirectly – `Names("CellName")`
- Ask the user to select the `Range` to use

-
- Use a function to get a reference – `Application.Index`
 - Search for the cell based on its function or value – `Find()`
 - Process a formula to determine the `Range` it depends on

In addition to those “simple” techniques above, there are more advanced techniques available. Those advanced techniques all rely on some combination of the above options, along with additional logic to manipulate the `Worksheet`. A couple of combination techniques would include:

- Use the Offset-Intersect technique to get a block of data without its header
- Use the `AutoFilter` to filter a data set and then get the visible cells with `SpecialCells()`
- Use one of the techniques above to get a `Range` on one `Worksheet`; grab the corresponding `Range` on a another `Worksheet` to do some processing

common aspects to working with a Range

There are several common aspects of working with `Ranges`. The most important thing is to remember the difference between using the `Range` as a reference or as a `Value`. The problem comes because VBA will work really hard to allow your code to execute regardless of whether the Value/reference part is done correctly.

The difference is best explained with an example. In this example, you can see that when the reference is stored, you must use the `Set` command. If you want the `Value` of a `Range`, you can either use `Value` or rely on VBA calling it implicitly otherwise. If you attempt to assign the `Value` of a `Range` to a `Range` object, you will get an error. If you attempt to assign the `Value` of a `Range` to a `Variant` variable, it will work, but the variable will only hold the `Value`. That is, you cannot make further calls from the `Range` object model. This should highlight the importance of declaring variables with the tightest scope on the variable type. If everything is a `Variant`, VBA will let you get away with a lot; sometimes that flexibility will bite you.

TODO: add an example here

some simple techniques for finding a Range

The simple selection techniques consist of:

- Use the ActiveCell – `ActiveCell` (see later for why these are different)
- Use the selection – `Selection`
- Hard-code the address of a single cell – `Range("A1")` or `Cells(1,1)` (please don't use the latter)

-
- Name a cell and use that name directly – `Range("CellName")`

These are considered simple, but their simplicity means they are commonly used. These techniques can return a `Range` that represents either a single cell or multiple cells or a group of discontinuous cells. The one exception to this is the `ActiveCell`; it is always a single cell.

Selection and ActiveCell The `Selection` and `ActiveCell` commands both work based on what is currently going on with the active spreadsheet. In particular, they work on the current selection of the `ActiveSheet` in the `ActiveWorkbook`. For a normal workflow, the active sheet and workbook are the ones with focus (or that last had focus). When working through an involved workflow, you can control the `ActiveSheet` and `ActiveWorkbook`. In general, you should not use these commands in an involved workflow without a very good reason.

Selection `Selection` is a catch all object that refers to anything that is selected. If the current selection is a group of cells, then you get a `Range`. If instead the selection is a Chart, Shape, button, or some other non-`Range`, then you will get an error if you assume that it has type `Range`. When working with the `Selection`, it is always good to assign a new `Range` variable equal to the `Selection`. This ensures that you get Intellisense for commands and also ensures that VBA will throw an error if the `Selection` is something other than a `Range`.

ActiveCell The `ActiveCell` always refers to a single cell. If the current `Selection` is a single cell, then these will refer to the same `Range`. If the current `Selection` is a multi-cell `Range`, then the `ActiveCell` is the cell that currently has focus. When normally editing cells, you have some control over which cell in a multi-cell `Range` is active. This can be changed by hitting `CTRL+.`, `SHIFT+Enter`. This functionality in Excel is what allows an array formula to be applied to a larger range. You select a multi cell `Range` and then enter the formula with `CTRL+SHIFT+Enter`. This in turn will apply the formula to all cells.

TODO: what happens when the `Selection` is not a `Range`? Does this still work?

Hard-code a cell reference

The second most common way of getting access to a `Range` is to simply give Excel the address of the `Range` to work with. This is a convenient way of working with `Ranges` because it can be easily checked against normal Excel formulas and addresses. The common ways of doing this are using the `Range` and `Cells` functions with the appropriate parameters.

When working with these functions, it is possible to use them “bare” or unqualified. That is, you can just type `Range()` or `Cells()` and it will work. Specifically, it will work on the `ActiveSheet` of the `ActiveWorkbook`. This can lead to some difficulties when working with multiple `Worksheets` or `Workbooks`. If you are working across contexts (`Worksheets` or `Workbooks`), you should generally qualify your reference to the widest context required. This is done by calling the appropriate function on the appropriate object/context. If you have multiple `Worksheets`, you would call `Worksheet.Range()` or specifically `Sheets("SheetName").Range()` in order to access a `Range` on that specific `Worksheet`. If you are working with multiple `Workbooks`, you still only need a reference to the `Worksheet`, but you will have to go through the correct `Workbook` first. This looks like: `Workbooks(1).Worksheets(1).Range`. If you’ve previously stored a reference to a `Worksheet`, you do not have to use the `Workbook` also; it is very common when working across `Workbooks` to store a `Worksheet` reference as you go (for this reason).

This caveat about qualifying a reference brings up an important point: a `Range` can only refer to cells that are on the same `Worksheet`. You are not allowed to create a `Range` across multiple `Worksheets`. (TODO: what happens if you try this?). If you want to work with `Ranges` on multiple `Worksheets`, you will need to iterate through the `Worksheets`.

Range() The `Range()` function is the powerhouse of cell referencing. It works hard to take whatever you give it and return a valid cell reference. It can process the same commands as the address bar in Excel. That is, it will parse:

- a cell reference (`A1`)
- a multi-cell reference (`A1:B5`)
- a discontinuous reference using a union (`(A1, B1, C1)`)
- a discontinuous reference using an intersect (`(A:A 1:1)`) – Note this will return the cell `A1` which is at the intersection of the two given references. Also note that this way of referencing cells is incredibly rare (I’ve never used it in a real application).
- a named range (`some_named_range`)
- any application of the multi cell references with named ranges

TODO: can the `Range` handle a function in it?

Alongside that power of the `Range()`, you can also use it to refer to a group of cells using the corners of the `Range`. This can be used to either return a group of cells in the same row/column, or it can be used to grab a block of data. You are free to give the cells in whatever order you’d like (not required to be top left and bottom right).

This multi-cell version of the `Range()` function is quite powerful when you know or can determine the corners of the `Range` you want. In particular, this works well with the `End()` and `Offset()` functions to build `Ranges` from a single starting point.

If you thought the `Range()` couldn't get any better, it has one last trick up its sleeve. It can also take parameters that are of the `Range` type when building a multi cell `Range`. This is quite powerful because it means you can use any of the techniques to find a `Range` and then get a block of data by feeding them to the `Range()` function. This saves the hassle of calling `Range(someRange.Address, someOtherRange.Address)` just to build the block.

There is one approach to using the `Range` function that is effective but can be a bad crutch. It involves building a `String` to feed to the `Range()` function. This usually looks like `Range("A"& Cells(1,1).Column)` or something similar. There are legitimate cases where this is a quick and easy way out of a problem. It generally involves knowing that you want a cell from a specific row or column while also knowing the other piece (column or row) from an existing cell. You can quickly combine the two to get your reference. There is nothing wrong with building a `String` here, but it might be a sign that there was a better way to get the reference from the start. It can be helpful when working with far to the right columns that are not easily thought of as a number; what column is `AB6` again?

When considering whether and how to use the `Range()` function, the main things to consider are:

- How stable does this code need to be?
- How likely am I to change the address of the cell I want?
- Will a given cell always be in the same place?
- Will a given name always exist?

These questions are pointing to some of the downfalls of `Range()`. The biggest downfall is that if you are going to use `Range("A1")` to refer to cell `A1`, your VBA code will not work if that cell moves for some reason. Furthermore, it can be a real pain to identify when code is failing because of a bad cell reference. I've had it happen countless times now where I hard-code a cell reference, use that in VBA, and then break things completely by adding a row or column somewhere. This is akin to using `VLOOKUP` and inserting a column in the middle of the lookup range; your code will not know or adjust to the new reference. Even worse, depending on what your code does, it's entirely likely that it will run just fine with the mistake. This is the most pernicious type of error to debug in a complicated program.

The upside of this dilemma is that you can quickly remedy the situation by using a named range to refer to the cell. If you name the cell on the Excel side of things, you get the benefit of Excel moving the reference around if the underlying cell moves. This is an incredibly powerful technique. More emphatically, this is the fastest way to "level up" your VBA if you are just getting started. Robust VBA generally relies on

named ranges on the underlying spreadsheet. It takes very regular spreadsheets to get away hard-coded references. As a tip, the second time you manually increment 10+ `Range("A1")` calls because of a new row is the last time you want to do that.

A common technique for building macros quickly is to start with hard coded references and convert them to named ranges once the spreadsheet takes form. There is nothing wrong with naming ranges early and not needing them, but it can take more time than it's worth to name the ranges instead of hard-coding a reference. Again, this can burn you quickly if you have to manually change several of those references.

Cells() A convenient but less powerful version of `Range()` is the `Cells()` function. `Cells()` is much simpler since it only requires a row or column number for the reference. This can be useful to quickly grab a reference if you know the row or column number (or both). It's far more likely that you know the Excel reference you want – `A1` – than that you know the exact row and column number. It's the column number that is always a pain to determine. Some folks try to get around this by using the `Asc()` – 65 approach to get the number for the letter and send that into `Cell1()`. Once you know about the `Range()` function, you'll never touch that madness again.

So, if the `Range()` function is typically more useful and powerful than `Cells()`, why would you ever use `Cells()`? Well, `Cells()` is the entry point for iterating through the cells in a multi-cell `Range`. This use of `Cells` will be covered later on, but it's mentioned here because it's incredibly powerful in that context. Specifically, if you have a `Range` already, you can use `Range.Cells()` to grab a cell within that `Range` at the specific spot. In this way, `Cells()` is actually useful because the indices are smaller and typically correspond to the actual application at hand. Again, this is covered later.

TODO: add a link to the section where iteration is covered

some simple techniques for finding a multi-cell Range

The simple selection technique for working with multiple cells consist of:

- Iterate through all cells – `Cells`, `UsedRange`
- Building a range from the corners – `Range()`

The previous section identified the simplest techniques for obtaining a reference to a `Range`. Those techniques touched on single and multi-cell `Ranges`. There are a couple of additional techniques for obtaining a multi-cell `Range` that are used commonly.

The typical goal of these multi-cell calls is to take the reference and iterate through the cells. To iterate through the cells, there are two techniques, `For Each` and `For` loops. The former is vastly preferred to the latter in nearly all cases. I'll say that again, if you're iterating through cells, you should strongly prefer to use a `For Each` loop instead of a simple `For` loop. Those two examples look like:

TODO: add code samples for `For` and `For Each` loops

Cells The `Cells` call exists on several different objects. The easiest way to access it is via the bare, unqualified, reference – just type `Cells`. It applies to the `ActiveSheet` of the `ActiveWorkbook`. Typically, you should avoid iterating all `Cells` unless you know you will break out of the loop at some point. There are a lot of cells in a `Worksheet`, and your code will grind to a halt working through rows 10100 to 132000 doing a bunch of nothing on empty cells.

UsedRange `UsedRange` is available on a `Worksheet`. It also exists as a bare unqualified reference applying to the `ActiveSheet` of the `ActiveWorkbook`. The `UsedRange` is a slightly complicated function but its goal is to provide you a `Range` that provides a bounding box on all of the used cells in the current `Worksheet`. The complication of `UsedRange` comes when determining what is a “used” cell. Excel will consider a cell used if it has a non default property for its value or formatting. The formatting part of the definition can throw you for a loop because it's possible to change the formatting in a non-obvious way (e.g. it's impossible to spot the font size of an empty cell). There are several well-regarded folks who will advocate against the `UsedRange` in all cases. Their argument is that the `UsedRange` is too undependable because it can be thrown off too easily. In my experience, the `UsedRange` is a powerful way to leverage Excel tracking the internal state of the spreadsheet. You can also avoid most of the issues with the `UsedRange` not matching expectations by taking care of the state of the spreadsheet. If a `Worksheet` was under your control, there's no reason to avoid the `UsedRange`. As a first tip, the `UsedRange` matches the scrollbars around the spreadsheet. If the scrollbars stop scrolling when you reach the “end of the spreadsheet”, then the `UsedRange` is good to go. You can also do a quick test with `UsedRange.Address` or `UsedRange.CountLarge` to see what it refers to. Again, I think the arguments against the `UsedRange` are overly cautious, and it's a great command in a well managed spreadsheet.

TODO: is `UsedRange` available bare?

finding a Range while iterating through a Range

One technique for working with Ranges is to start with one Range, iterate through it, and build a new Range based on some criteria. Alternatively, you may just act immediately on the Range as you are iterating through it. This approach is dead simple and is used in abundance throughout good workflows. As long as there is some meaningful logic which can be applied to identify whether or not a subset of a Range is interesting, you can use this technique. Some common logical steps that are checked:

- Check the **Value** of the cell
- Check if the cell has some property (e.g. **HasFormula**, **HasArray**, etc.)
- Check the **Style** of the cell

The idea is simple: check some property while iterating and act on it. This is obvious once you have been programming for a bit, but sometimes you just need to be told that this is an acceptable way of doing things. You do not always need to use **Find** to search for a cell that contains some value. You can always just iterate all the cells and see if a cell matches that value (or contains it with **InStr**).

TODO: find some code related to this?

finding a Range by paring down (or up) an existing Range

One of the key ways to access a **Range** is to use an existing **Range** and modify it slightly. This might prompt the question: how do I get the first **Range** in order to use that? Well, check the previous section for the most common techniques. You can always start with **ActiveCell** if you just want to see these in action.

Using a **Range** to get the next **Range** really is the bread and butter of serious VBA development. It is a very common pattern to identify a single **Range** in a **Worksheet** that is critical to the rest of the spreadsheet and use that as an “anchor” to access the rest of the cells. This is particularly common when the data is structured in some way that can be utilized.

When using these techniques, there are a couple of common strategies. They work by either paring down the current **Range**, moving the current **Range**, or using the current **Range** as the start of some expansion. Of course, since a **Range** can be used to access a **Range**, you will quickly find yourself chaining these functions together. That is the true power of these techniques. Very often you will use 2 or 3 to take a single cell, move to a new spot, resize to cover all of the data and then move over a column to do something.

- Take an existing **Range**, possibly all cells, and pare it down using: _ Move from a known cell to a new spot – **Offset()**, **End()** _ Take a subset of an existing **Range** – **Cells**, **Rows**, **Columns**, **Areas** _ Take an existing **Range** and change its size – **Resize()** _ Take a super set of an existing **Range**

– `EntireColumn`, `EntireRow`, `CurrentRegion`, `CurrentArray` * Allow Excel to filter the `Range` based on things it tracks (e.g. value, blank, hidden, etc.) – `SpecialCells()`

move to a new spot, `Offset()` and `End()` There are two simple ways to “move” from a given `Range` to a new `Range`, namely using `Offset()` and `End()`. Both of these take an existing `Range` and return a new one. `Offset()` will not modify the size of the current `Range`; it will just move it. `End()` will always return a single cell even if the starting `Range` was multi-cell.

`Offset()` `Offset(rows, columns)` works by moving the given `Range` over by the parameters given to it. The nice thing about `Offset()` is that the parameters can be negative to move backwards. There are a couple of simple use cases for `Offset()`:

- Work your way down or across a group of cells, by `Offsetting()` and setting a reference to the new cell _ This is often paired with a `While` loop to work down a `Range` _ This is also helpful when you are not exactly sure what `Range` you want (maybe it’s dependent on cell values) so you can’t simply assign the correct multi-cell `Range` at the start.
- Use an existing `Range` to get the starting point for a `Range` and move over to a neighbor cell or a blank area to do something _ This is common when using one cell’s value to determine the value of the next one (e.g. splitting on a delimiter) _ This is also common when adding formulas to a spreadsheet. Find the current data, `Offset()` over a column and apply the formula to all cells.
* Also helpful when you “just know” that a desired `Range` is some distance away from the `Range` you’ve got. This is not the most elegant code at times (since it breaks easily), but it works reliably when you control the spreadsheet.

TODO: add a while loop example TODO: add a formula example

`End()` `End(xlDirection)` is a powerful function for its specific use case. It replicates the functionality of the `CTRL+Arrow` keyboard shortcuts. It will move from the current `Range` as far as possible in a given direction so long as the cells are contiguous. Contiguous in this sense refers to the fact that the cells must not have a blank cell in between them. A blank cell is any cell that does not have a value or a formula. The formula part is important because you can use a formula to return `""` while still counting as a contiguous `Range`.

`End()` takes a parameter which is the direction to travel in. You can go all 4 directions, up/down and left/right.

`End()` will always return a single cell as the reference. This often means that `End()` is used alongside a `Range(Range, Range)` to get a multi-cell `Range` that spans from the start cell to the end cell. This is so common of a pattern, that I typically add a UDF that handles this logic directly.

TODO: add the function that is used `RangeEnd`

There are a few common patterns when working with `End()`:

- Use a `Range` that you know is at the top of a block of data and use `End(xlDown)` to get to the bottom of the column. _ This can be combined with `Range(Range, Range)` to get the full multi-cell `Range` to work through _ This technique is very powerful when redefining the `Ranges` of a chart to include all of the cells (this can also be used for formulas too).
- If you know your data has blanks, you can use `End()` to jump to the next non-blank cell. * This is helpful if you are trying to fill in blank cells (TODO: add the Waterfall fill here)

RangeEnd.md

```
1 Public Function RangeEnd(ByVal rangeBegin As Range, ByVal firstDirection As
  XlDirection, Optional ByVal secondDirection As XlDirection = -1) As Range
2
3     If secondDirection = -1 Then
4         Set RangeEnd = Range(rangeBegin, rangeBegin.End(firstDirection))
5     Else
6         Set RangeEnd = Range(rangeBegin, rangeBegin.End(firstDirection).End(
          secondDirection))
7     End If
8 End Function
```

RangeEnd_Boundary.md

```
1 Public Function RangeEnd_Boundary(ByVal rangeBegin As Range, ByVal
  firstDirection As XlDirection, Optional ByVal secondDirection As
  XlDirection = -1) As Range
2
3     If secondDirection = -1 Then
4         Set RangeEnd_Boundary = Intersect(Range(rangeBegin, rangeBegin.End(
          firstDirection)), rangeBegin.CurrentRegion)
5     Else
6         Set RangeEnd_Boundary = Intersect(Range(rangeBegin, rangeBegin.End(
          firstDirection).End(secondDirection)), rangeBegin.CurrentRegion)
7     End If
```

Take a subset of an existing Range – Cells, Rows, Columns, Areas The subset functions work by providing you with a Range that is created from another Range based on some condition. They can be quite useful for building a workflow that makes it very explicit how you are trying to iterate through a Range or what you are searching for. The idea is that you know your starting Range contains some pieces that you would like to iterate through. The grouping goes from smallest unit to largest:

- Cells will return a “flat” list of all cells within the Range. No grouping left.
- Rows and Columns will each return a new iterable object built of the previous Range sliced into its Rows or Columns. If call them in order, it will look the same as iterating through Cells except that the order may be different (TODO: how does this work?). Be sure that if you want to use these, avoid the properties with the “s”. If you call Row or Column, you will just get a number instead of a group of Ranges
- Areas will return a group of cells that may contain groups of Rows or Columns or just individual Cells. Areas are commonly built by users using CTRL to select multiple things or by VBA which uses `Union` to build Ranges.

TODO: add some specific code related to Columns and Rows... that code is quite useful as a replacement to `Cells(i,j)`

TODO: give an example of using Areas

Take an existing Range and change its size – Resize() `Resize()` is a straightforward function that does exactly what you expect. It takes a current Range and resizes it to contain the number of rows and columns specified. The most common uses of a `Resize()` are:

- You know where you want some output to start and its size, so you `Resize()` to get a Range that will hold all of the data.
- You know that some data starts at a given cell and its size, so you `Resize()` and call `Value` to get an array of that data.
- You would like to extend or change a formula based on some condition, so you `Resize` and apply the formula down the line

In general, these uses follow a pattern: you know what size you want the Range to be (or can compute the size) and `Resize` gives you the Range back. This is one of the least controversial of the Range methods. Enough said.

TODO: how does this handle negative numbers TODO: how does this handle a multi-cell range, does it always pick top left?

Take a super set of an existing Range – EntireColumn, EntireRow, CurrentRegion, CurrentArray These “super set” functions work by taking a starting point and expanding it to include more cells. These will grow the [Range](#). Of the four listed above, [CurrentArray](#) is the only one that requires some special case. That is, the current cell must be a part of an array formula. The others will always work. These functions are best thought of with their keyboard shortcut equivalents:

TODO: extract this table along with others and make a single big table somewhere

shortcut	Range function
SHIFT + SPACE	EntireRow()
CTRL + SPACE	EntireColumn()
CTRL + A	CurrentRegion()
CTRL + /	CurrentArray()

[CurrentRegion](#) is really only as useful as the data on the spreadsheet. If you have a large block of data, it works well to get the entire region. If you have blanks in your data, it’s a bit of an unknown to know in advance what [CurrentRegion](#) will give you. Typically, if you know you have a block of data, it can be a quick shortcut to using [End\(\)](#) twice. In general, I avoid it.

[EntireRow](#) and [EntireColumn](#) are somewhat special because they can be used to make modifications to the rows and columns in Excel. In particular, they are needed if you want to insert a row/column, delete a row/column, change the row/column formatting, or change the height/width of the row/column. You can also use [Range\("A:A"\)](#) or similar to get a reference to the entire column, but it is much simpler to have a reference to a [Range](#) of a single cell and work out from there. Even better, if you have a multi-cell [Range](#), the [Entire](#) functions will return the combination of all the rows or columns contained in the [Range](#).

In addition to modifying the rows/columns of a [Worksheet](#), the [Entire](#) functions also work very nicely with [Intersect\(\)](#) to get group of cells that are in a specific row/column. The [Entire](#) functions are generally much nicer than trying to build the [Range](#) from address or any other technique.

TODO: is this true? Does it work for a multi-cell in this way?

Allow Excel to filter the Range based on things it tracks (e.g. value, blank, hidden, etc.) – SpecialCells() The final function in this round up is also the most powerful at times: `SpecialCells()`. This function works by taking a parameter how which “special” cells to return. Special is a bad name here, because the most common uses of `SpecialCells` are to grab cells that are formula, values, blanks, or visible. These are some of the more mundane properties of a cell. Name aside, `SpecialCells()` can really take your VBA to the next level with very little effort.

An example: if you have ever iterated through `UsedRange` or `Cells` with something that checks for `rng.Value = ""` then you could have saved a loop by using `SpecialCells(xlCellTypeBlanks)` instead. This will return a new `Range` that only contains the blank cells. There are similar special types for other things that commonly come up.

One particular application of `SpecialCells` is when working with the `AutoFilter` which will cause rows to be `Hidden`. You can get a `Range` that contains all of the visible rows which is the same as the rows which satisfy the filter. If your data is well structured or can be filtered, this ends up being a great way to push the burden of filtering onto Excel instead of having all that logic in VBA.

You can also use `SpecialCells` to quickly return a list of those cells which have a value (or formula) if you have a large block of sparse data. Once you have all of those cells, you can `Intersect()` the `EntireColumn` (or row) with the header of the data. This allows you to move quickly through data without having to build addresses or remember where specific things are. In general, this highlights an important strategy: if you can obtain `Ranges` with the areas that are critical, you can quickly manipulate those `Ranges` to perform some action. You can spend less time building finding cells and `Ranges` once you know how to work and combine these functions.

TODO: add the table manipulation code here to give an example of that TODO: consider adding an example of using `SpecialCells` with filtering

working with a Range via Union and Intersect

You can perform set operations on multiple `Ranges` using `Union` and `Intersect`. Like all set operations, they correspond to different sections of a Venn Diagram. The simpler example is using `Union` since it will always return a new valid `Range` if it was fed valid `Ranges` to start. It works by growing the `Range` into a new `Range` that includes all previous objects referenced.

`Intersect` is a different beast because it is possible for it to return `Nothing` if the given `Ranges` do not actually intersect. This is actually a very useful property if you are trying to confirm whether or not a given cell is within another `Range`.

TODO: add a picture of set operations

Some common examples of where these functions come up:

- Intersect is used with Events and other usability tasks to determine if a given or selected Cell is within a target Range
- Intersect is very useful with Offset and Resize to grab a new Range that contains a subset of data of the original Range without having to worry about creating a new Range that includes cells not previously included. In this sense, Intersect only allows a Range to get smaller.
- Union can be very helpful when building a larger group to change all of their properties at once. This is quite nice because Excel will “batch” the calculations if you change the `Value` all at once. This same technique can be used to build a Range to delete

TODO: add Union-Delete example

TODO: add Intersect example to remove headers

TODO: add Intersect technique for Events and Selection changed

the kitchen sink of remaining Range ideas

- Pull the `Range` reference from some other object
- Name a cell and use that name indirectly – `Names("CellName")`
- Ask the user to select the `Range` to use
- Use a function to get a reference – `Application.Index`
- Search for the cell based on its function or value – `Find()`
- Process a formula to determine the `Range` it depends on

TODO: look into the Trace functions to see what they return

Objects that will return a Range One of the greatest consistencies throughout VBA and the Object Model is how various objects will return a new object or reference to a useful property. At times, this can save you a large chunk of time trying to recreate that access from scratch. The key then is knowing when these properties exist and how to use them.

Below is a rough summary of objects that will give you access to a Range.

- TODO: create this list
- TODO: consider making this a cheat sheet or similar since it covers most of the sections in this chapter

In addition to objects that will return a Range, there are also objects which will not return a Range but should. These include:

- TODO: create the rest of this list
- Chart Series info related to the Name, Values, and XValues. You are required to work through the `=SERIES` formula instead

Using `Names().RefersToRange` There are two ways to work with named ranges. One of them is quite simple: `Range("SomeNamedRange")`. This works well in a couple of cases:

- You know the exact name you want to use or can prompt the user for it
- You are using the `Range` call on an object that has proper scope.

For the latter point, the default named ranges have `Workbook` scope and the `Range` call works across the board. This becomes more of an issue when you are using the same name across multiple Worksheets with a Worksheet level scope. You can still access the named range, but now your call to `Range`, needs to be `Worksheet.Range` from the correctly scoped Worksheet.

The former point about needing to know the name is more often the problem. Sometimes you want to help someone use a named range, but you simply do not know what they are named. One trivial example is creating an addin that outputs all of the named ranges in the Workbook. You cannot iterate them through `Range` because you want to know what they are!

When you are in a position where you want to use the named ranges but do not know or want to use the actual names, you can go directly through the `Names` object. There are two ways to do this:

- Iterate the `Names` with no knowledge of them
- Use an index, i.e. the `Name` and call into `Names(index)`

Once you have access to a valid `Name`, you can then access the `RefersToRange` which will return a Range that can be used. There are few instances where this is ever going to be better if you already have the name. The one exception to this is if you are wanting to change some of the metadata associated with the Name. This mainly includes the comment on the name since there is not much else. Another option is that you can copy the named Range as a new range with a slightly different name. I have done this before to process all of the named ranges into some new named Range based on a formula which included the previous one. This can be a critical step to improving the performance of array formulas that previously pointed to entire columns. The problem is that creating the dynamically named ranges is an absolute pain without VBA.

TODO: add an example of the dynamic name creation

Once you are comfortable accessing named ranges, you may find that it is helpful to create them from time to time from VBA. This can be a helpful way of storing a complicated Range that your VBA created without having to select the cells and hope you can type the name correctly.

Using Application.InputBox(, Type:=8) One very useful technique for obtaining a Range is to ask the user for one. This is one of the fastest ways to level up your VBA game because it provides the user control while also making your VBA look pretty slick with the Range picker. The other upside here is that the InputBox Range picker generally works better than the RedEdit version on a form. The odd thing here is two-fold:

- You have to know that InputBox exists on the Application alone. If you use the other version, then you cannot supply the Type
- You have to know that Type:=8 allows for a Range selection

Once you have those two things down (because you read this book!) then you are able to ask the user to pick a Range with ease. The other very nice thing about the InputBox approach is that you can supply a default address (not Range) and it will automatically be selected at the start. I have used this approach to get effect in BUTL to allow the VBA to process the Selection (by default) or to allow the user to select something different. This is a very clean solution to sneaky defaults while also allowing the user to do something different once they read your initial prompt. It is also dead simple to upgrade your current `Set rng = Range()` to `Set rng = Application.InputBox("Select a cell", Type:=8)` instead. For utility type code, the difference is immense in terms of not having to hard code or guess Ranges. Or you can still guess them but provide the user a chance to change the guess.

TODO: move that Function here from BUTL GetOrSelect...

Using Application.Index The `=INDEX` formula is the most potent formula in Excel. Its counterpart in the VBA world is also powerful but less impressive compared to real programming. Having said that, the `Index` function works exactly as expected in VBA and is a very nice tool to have if you are comfortable using INDEX in a normal spreadsheet. The real power of Index is that you can use it to replace a lot of the common code where you iterate through a Range until you find a given value. One potential upside of Index is that you can upgrade an Excel only methodology over to VBA with minimal change to formulas. Once you have the work converted over, you can then set about adding the details that VBA alone can provide.

TODO: does this work any different than Cells? is it really that useful?

Using Range.Find() I seldom use `Range.Find()`, but it can be a powerful addition when you know what you want to search for. My problem with `.Find` is that it is incredibly rare that I have some free text I am searching for and want to find using VBA. Generally speaking, `Find` becomes useful when you are processing a somewhat arbitrary Worksheet which may contain certain data you want. In my experience, I am far more likely to use an `AutoFilter` or something other than `Find`. Part of the problem for me is that I have never had a problem using some other method than `Find`. I also generally find myself somewhat confused by the parameters and the general execution of `Find`. Typically, you will need to create a `While` loop to search for the next found items.

I also have the (probably unfair) view that `Find` is a crutch to not being able to use other methods to find a given Range. I generally prefer to iterate through cells and check values. My mind is built around building a Range and processing it rather than attempting to find a Range and then process it. Your mileage may vary.

TODO: add an example of using `Find` correctly

Pulling a Range from a Formula with string processing One of the next level things to do with VBA is to start processing your Formulas to drive your VBA. There are a couple of places where this might be useful:

- You are dealing with a Chart Series Formula which must be parsed
- You want to Trace the precedent cells but don't want to deal with `TracePrecedents`
- You want to modify some part of the formula (e.g. take `A1` and surround it with an `ABS(A1)`)
- You want to make all of the cells in a specific formula a specific color (like a permanent version of hitting `F2`)

Whatever your motivation, it's good to remember that the formulas in a spreadsheet are generally the most important information aside from the actual data. In some spreadsheets, the formulas are the only important part. If you want to extract and use this information, then it is helpful to be able to parse the formulas and identify the Ranges.

There are a couple of approaches to parsing Ranges from formulas, depending on what you need to do and what you start with:

- Your formulas contain only A1 style references without sheet names
- Your formulas may contain a sheet name too
- You want to extract non-range formula information

For the first two, you can build relatively simple parsers which can extract the Range information with good accuracy. The key here is to understand exactly what your formulas look like. The worst case is having

to build a full out formulas parser which is a non-trivial exercise. Handling all possible Excel syntaxs is a mess.

If you can settle for something less, then you have a couple of approaches at hand:

- Use a Regular Expression keyed in to Range options
- Use your knowledge of the possible formulas to extract the relevant parts with string functions

TODO: add an example of some Regex which work here... expanding complexity

TODO: add an example of parsing out with Split and Left or something

working with Ranges via advanced techniques

- Use the Offset-Intersect technique to get a block of data without its header
- Use the `AutoFilter` to filter a data set and then get the visible cells with `SpecialCells()`
- Use one of the techniques above to get a `Range` on one `Worksheet`; grab the corresponding `Range` on another `Worksheet` to do some processing

Offset-Intersect The Offset-Intersect is one of the most useful and simple approaches to creating a Range. The idea is that by using Intersect, you will avoid ever creating a Range that is bigger than some starting point. This means that you will not be able to accidentally add a blank or neighboring column to your Range. Knowing this, you can then take whatever steps are necessary to “remove” bad sections from your Range. This is most commonly used to remove a header row from the top of a Range. If you are using Offset, the only rule is that you must make a valid move before calling Intersect. To remove a header, assuming you have a range which is a block of data with headers, simply do: `Set rng = Intersect(rng, rng.Offset(1))`. This gives you a new Range which has all of the cells of the first one except for the first row.

TODO: add an image of how this works

Intersect used in this fashion is incredibly powerful. You can do all sorts of wacky steps to filter out a Range and then Intersect against the original Range to ensure that you have not accidentally stepped outside your starting box.

AutoFilter and then SpecialCells This approach is straight forward and mirrors a common operation in non VBA Excel. You use an AutoFilter to filter out specific cells and then you can select only the visible cells. In Excel, you can use `ALT+SEMICOLON` to only select visible cells. Often times, you will not need to actually

do this since Excel tries to help you when dealing with Hidden rows and columns. Typically Excel will not apply formatting to hidden cells and will also not fill a formula through them (assuming you used the Fill command).

In VBA, things are often more difficult because you are working with the underlying Range independent of whether or not the cells are hidden. To get around this, Excel provides the `SpecialCells` function which allows you to select a subset of cells based on some criteria. When using the AutoFilter, the most common criterion to use is that of visibility. You can call `Range.SpecialCells(xlCellTypeVisible)` to obtain a new Range which only contains visible cells.

If you have ever written a loop which does a `If rng.Hidden = True Then...` then you will be grateful to know that Excel VBA provides this feature automatically. `SpecialCells` really is one of the most powerful ways to access Ranges in an intuitive fashion that matches normal Excel.

The Duplicated Range on another Sheet If you are working with multiple sheets that are the same, similar, or related, you will often find yourself using information about one sheet to build a Range on another or several others. The problem with Ranges however is that they are not allowed to span multiple Worksheets. This means that if you want to apply some action to each `A1:A10` Range on each Worksheet, you will need to do it iteratively. This can be a pain however if you built your Range using code and not a direct address. To get around this, you can use the `Range.Address()` function to obtain an address for the Range. The trick here is to use the `Address` function without parameters which will give you the local address without a Worksheet name. You can then use that address on each of the other Worksheets, you access the given cells on that Worksheet.

This is a nice way to replicate the functionality of Excel where you can select multiple Worksheets with CTRL or SHIFT and then apply some action to all of them. The really nice thing about VBA however is that you can apply an action that is aware of the Worksheet on which it is acting. This is quite nice because the normal multi-edit feature does the exact same steps to all spreadsheets whereas you may want to use `End` or something in your code.

Range via user input: InputBox

This section will focus on obtaining a Range from user input via the `Application.InputBox`

TODO: clean up this code

GetInputOrSelection.md

```
1 Public Function GetInputOrSelection(ByVal userPrompt As String) As Range
2
3     Dim defaultString As String
4
5     If TypeOf Selection Is Range Then
6         defaultString = Selection.Address
7     End If
8
9     On Error GoTo ErrorNoSelection
10    Set GetInputOrSelection = Application.InputBox(userPrompt, Type:=8,
11        Default:=defaultString)
12
13    Exit Function
14
15 ErrorNoSelection:
16     Set GetInputOrSelection = Nothing
17 End Function
```

overview of 2 values and formulas

Values and formulas will focus on what to do with a Range after you have it. This typically falls into a couple of categories:

- Do some control logic based on the value of the Cell
- Apply some formatting to the cell
- Modify the formulas of the cell
- Manipulate the cell or its neighbors in order to produce a more useful result
- Transform the cells based on their content
- Do something specific to Excel with the [Range](#): conditional formatting, data validation, comment, hyperlink etc.
- adding or deleting a [Range](#) or possibly just using one of the clear function

In addition to those basic tasks, also include:

- Working with Conditional Formatting

-
- Combining some more advanced topics like using the data in a [Range](#) to manipulate something about a [Chart](#)

TODO: run through BUTL and see what other category of things there are

chapter 2 - 1, introduction to manipulations

This chapter will focus on the actual work of using [Ranges](#) for some purpose. This chapter is predicated on the previous one which focused on obtaining a [Range](#). When talking of “using” a [Range](#), the goal usually takes one of the following forms:

- Work through a spreadsheet of data, processing it from one format into another. This can be to pull data out, do calculations on a subset of data, change the formatting, aggregate data, summarize data into a new spreadsheet, etc. The options here are really endless, but the main idea is that you have an existing spreadsheet of data to do something with.

The next category of work is to process some small amount of data in place, typically to clean up data or convert it to some other form. A lot of this type of work is providing some functionality that would be great to have in Excel by default. This work also includes a lot of very specific types of functions that only make sense with your data. In that sense, these types of actions can be the quickest hitters; they are specific to your task and easy to program.

Another category of work is to run through an existing worksheet and perform some amount of checking on it. These checks do not necessarily need to modify the spreadsheet, they can be checking for formula errors, bad values, etc.

Another type of work that can be done is to modify the spreadsheet to make it easier to do work or to manage a workflow. These types of things are often implemented as events, but they can just be stray macros as well. When modifying the spreadsheet, you are often showing/hiding columns or worksheets. You can also be sorting [Worksheets](#). You might be moving some number of [Worksheets](#) over from a “template” and setting up a common work environment. You may also be d

As we progress down this list, things are becoming increasingly complicated. At some point, the work involved will progress from a couple of simple tasks to a much more involved workflow. It’s generally the nature of a complicated workflow that it is simply doing a long string of simple tasks all at once. In that sense, if you can learn these techniques, you can start to become comfortable combining them in more complicated fashions.

simple manipulations (one steppers)

This section will focus on simple manipulations. Simple manipulations generally take a two step process: identify a [Range](#) to work with and then do something to that [Range](#). In a lot of cases, the [Range](#) contains multiple cells and may be iterated through a cell at a time to apply the action.

These simple manipulations truly are simple. It includes things like:

- Change the value of a cell
- Change the value of a group of cells
- Change the formula of a cell
- Change the formatting of a cell
- Clear the formatting or value from a cell
- Return some piece of information about a cell

TODO: deal with these later

Name a group of cells Add a hyperlink to the current cell

TODO: add a couple examples of the simple manipulations

slightly more complicated manipulations (the two steppers)

This section will on the so called “two steppers”. I call them that because these manipulations typically involve two commands after identifying a [Range](#). the first command is usually a logic or loop, and the second command is the actual work to be done. Two steppers are important because a large number of complicated tasks involve nesting and combining these two steps.

Some examples of two step manipulations includes;

- Run through a list of cells, if the text is numeric, convert to a number
- Run through a list of cells, if the cell is blank, fill with the value from above
- Run through some cells, check if the row is odd or even, and color the row from one of two colors
- Run through one list of cells, apply the formatting to the same cell in a different column

TODO: find some better examples for these as well

strategy #1, do something if

This strategy really is the core of all advanced VBA development. It's simple enough: "do something, if". The endless possibilities come from the choices for "do something" and the things that could be checked in the "if". There are a handful of common scenarios that are best covered by storing some utility code (e.g. convert to a number if numeric). Most of these two step solutions though are specific to the task at hand.

In this section, the goal is to show the general form of this strategy with a couple of examples.

TODO: add a couple examples of this

strategy #2, work through one Range and apply to another Range

This strategy comes up frequently when working through [Ranges](#) that are related somehow. The general idea is that you want to apply an action in one [Range](#) based on something about another [Range](#). The simplest case of this is to move a value from [Range](#) to another. This simple case sometimes reduces to not much more than copying and pasting. Having said that, once you get past the simplest version of it, you will be doing something that copy and paste cannot handle.

TODO: add a couple examples of this

things to change and check

This section will focus on the common properties that are checked and changed with these types of manipulations.

properties of the Range

The common properties of the [Range](#) to work with include:

- Value
- Text
- Formula
- Font
- Interior
- NumberFormat

TODO: add some examples of working with these

commonly used VBA functions

In addition to the properties of the [Range](#), there are a handful of common VBA functions that come up when working with simple to moderate manipulations. These include:

- Split - split a string into an array based on a delimiter (the reverse of Join)
- Join - join an array into a string with a delimiter (this reverse of Split)
- Asc - determine the ASCII code for a character
- Chr - return a character for an ASCII code (the reverse of Asc)
- InStr - determine if a string is in another one (called Substring in other languages)
- Left, Mid, Right - grab parts of a string
- Trim - remove any whitespace from the start or end of a string
- Len - determine the length of a string
- UCase, LCase - used to force a string to upper or lower case
- UBound, LBound - determine the bounds of any array
- WorksheetFunction - get access to any Excel functions in VBA
- IsNumeric, IsEmpty - check if a number – TODO: add the others here
- CDbl, CLng, CBool, CDate - convert a value of one type to another – TODO: add any others
- Replace - replace one string in another
- Application.Index, Application.Match - these are the VBA versions of the Excel functions
- Application.Transpose - convert a 1D array from vertical to horizontal and back
- Is Nothing - check if a reference has been set
- TypeName - check the type of an object (useful if working with [Variant](#))
- RGB - useful way to build colors from known red, green, and blue values
- Count - common way to get the size of a group, used often to resize an input/output or to check logic

TODO: search through bUTL for other common functions

CategoricalColoring.md

```
1 Public Sub CategoricalColoring()  
2  
3  
4     '+Get User Input
```

```

5 Dim targetRange As Range
6 On Error GoTo errHandler
7 Set targetRange = GetInputOrSelection("Select Range to Color")
8
9 Dim coloredRange As Range
10 Set coloredRange = GetInputOrSelection("Select Range with Colors")
11
12 '+Do Magic
13 Application.ScreenUpdating = False
14 Dim targetCell As Range
15 Dim foundRange As Variant
16
17 For Each targetCell In targetRange
18     foundRange = Application.Match(targetCell, coloredRange, 0)
19     '+ Matches font style as well as interior color
20     If IsNumeric(foundRange) Then
21         targetCell.Font.FontStyle = coloredRange.Cells(foundRange).Font.
                FontStyle
22         targetCell.Font.Color = coloredRange.Cells(foundRange).Font.Color
23         '+Skip interior color if there is none
24         If Not coloredRange.Cells(foundRange).Interior.ColorIndex =
                xlNone Then
25             targetCell.Interior.Color = coloredRange.Cells(foundRange).
                    Interior.Color
26         End If
27     End If
28 Next targetCell
29 '+ If no fill, restore gridlines
30 targetRange.Borders.LineStyle = xlNone
31 Application.ScreenUpdating = True
32 Exit Sub
33 errHandler:
34 MsgBox "No Range Selected!"
35 Application.ScreenUpdating = True
36 End Sub

```

ColorForUnique.md

```

1 Public Sub ColorForUnique()
2
3     Dim dictKeysAndColors As New Scripting.Dictionary
4     Dim dictColorsOnly As New Scripting.Dictionary
5
6     Dim targetRange As Range
7
8     On Error GoTo ColorForUnique_Error
9
10    Set targetRange = GetInputOrSelection("Select column to color")
11    Set targetRange = Intersect(targetRange, targetRange.Parent.UsedRange)
12
13    'We can colorize the sorting column, or the entire row
14    Dim shouldColorEntireRow As VbMsgBoxResult
15    shouldColorEntireRow = MsgBox("Do you want to color the entire row?",
        vbYesNo)
16
17    Application.ScreenUpdating = False
18
19    Dim rowToColor As Range
20    For Each rowToColor In targetRange.Rows
21
22        'allow for a multi column key if intial range is multi-column
23        'TODO: consider making this another prompt... might (?) want to color
            multi range based on single column key
24        Dim keyString As String
25        If rowToColor.Columns.Count > 1 Then
26            keyString = Join(Application.Transpose(Application.Transpose(
                rowToColor.Value)), "|")
27        Else
28            keyString = rowToColor.Value
29        End If
30
31        'new value, need a color
32        If Not dictKeysAndColors.Exists(keyString) Then
33            Dim randomColor As Long
34        createNewColor:
35            randomColor = RGB(Application.RandBetween(50, 255), _

```

```

36         Application.RandBetween(50, 255), Application.
           RandBetween(50, 255))
37     If dictColorsOnly.Exists(randomColor) Then
38         'ensure unique colors only
39         GoTo createNewColor 'This is a sub-optimal way of performing
           this error check and loop
40     End If
41
42     dictKeysAndColors.Add keyString, randomColor
43 End If
44
45 If shouldColorEntireRow = vbYes Then
46     rowToColor.EntireRow.Interior.Color = dictKeysAndColors(keyString
        )
47 Else
48     rowToColor.Interior.Color = dictKeysAndColors(keyString)
49 End If
50 Next rowToColor
51
52 Application.ScreenUpdating = True
53
54 On Error GoTo 0
55 Exit Sub
56
57 ColorForUnique_Error:
58     MsgBox "Select a valid range or fewer than 65650 unique entries."
59
60 End Sub

```

Colorize.md

```

1 Public Sub Colorize()
2
3     Dim targetRange As Range
4     On Error GoTo errorHandler
5     Set targetRange = GetInputOrSelection("Select range to color")
6     Dim lastRow As Long
7     lastRow = targetRange.Rows.Count

```

```

8      Dim interiorColor As Long
9      interiorColor = RGB(200, 200, 200)
10
11     Dim sameColorForLikeValues As VbMsgBoxResult
12     sameColorForLikeValues = MsgBox("Do you want to keep duplicate values the
13         same color?", vbYesNo)
14
15     If sameColorForLikeValues = vbNo Then
16
17         Dim i As Long
18         For i = 1 To lastRow
19             If i Mod 2 = 0 Then
20                 targetRange.Rows(i).Interior.Color = interiorColor
21             Else: targetRange.Rows(i).Interior.ColorIndex = xlNone
22             End If
23         Next
24     End If
25
26     If sameColorForLikeValues = vbYes Then
27         Dim flipFlag As Boolean
28         For i = 2 To lastRow
29             If targetRange.Cells(i, 1) <> targetRange.Cells(i - 1, 1) Then
30                 flipFlag = Not flipFlag
31             If flipFlag Then
32                 targetRange.Rows(i).Interior.Color = interiorColor
33             Else: targetRange.Rows(i).Interior.ColorIndex = xlNone
34             End If
35         Next
36     End If
37     Exit Sub
38 errHandler:
39     MsgBox "No Range Selected!"
40 End Sub

```

CombineCells.md

```

1 Public Sub CombineCells()

```

```
2
3     'collect all user data up front
4     Dim inputRange As Range
5     On Error GoTo errorHandler
6     Set inputRange = GetInputOrSelection("Select the range of cells to
       combine")
7
8     Dim delimiter As String
9     delimiter = Application.InputBox("Delimiter:")
10    If delimiter = "" Or delimiter = "False" Then GoTo delimiterError
11
12    Dim outputRange As Range
13    Set outputRange = GetInputOrSelection("Select the output range")
14
15    'Check the size of input and adjust output
16    Dim numberOfColumns As Long
17    numberOfColumns = inputRange.Columns.Count
18
19    Dim numberOfRows As Long
20    numberOfRows = inputRange.Rows.Count
21
22    outputRange = outputRange.Resize(numberOfRows, 1)
23
24    'Read input rows into a single string
25    Dim outputString As String
26    Dim i As Long
27    For i = 1 To numberOfRows
28        outputString = vbNullString
29        Dim j As Long
30        For j = 1 To numberOfColumns
31            outputString = outputString & delimiter & inputRange(i, j)
32        Next
33        'Get rid of the first character (delimiter)
34        outputString = Right(outputString, Len(outputString) - 1)
35        'Print it!
36        outputRange(i, 1) = outputString
37    Next
38    Exit Sub
39 delimiterError:
```

```
40     MsgBox "No Delimiter Selected!"
41     Exit Sub
42 errorHandler:
43     MsgBox "No Range Selected!"
44 End Sub
```

ConvertToNumber.md

```
1 Public Sub ConvertToNumber()
2
3     Dim targetCell As Range
4     Dim targetSelection As Range
5
6     Set targetSelection = Selection
7
8     Application.ScreenUpdating = False
9     Application.Calculation = xlCalculationManual
10
11     For Each targetCell In Intersect(targetSelection, ActiveSheet.UsedRange)
12         If Not IsEmpty(targetCell.Value) And IsNumeric(targetCell.Value) Then
13             targetCell.Value = CDbl(targetCell.Value)
14         End If
15     Next targetCell
16
17     Application.ScreenUpdating = True
18     Application.Calculation = xlCalculationAutomatic
19 End Sub
```

CopyTranspose.md

```
1 Public Sub CopyTranspose()
2
3     'If user cancels a range input, we need to handle it when it occurs
4     On Error GoTo errCancel
5     Dim selectedRange As Range
6
```

```
7 Set selectedRange = GetInputOrSelection("Select your range")
8
9 Dim outputRange As Range
10 'Need to handle the error of selecting more than one cell
11 Set outputRange = GetInputOrSelection("Select the output corner")
12
13 Application.ScreenUpdating = False
14 Application.EnableEvents = False
15 Application.Calculation = xlCalculationManual
16
17 Dim startingCornerCell As Range
18 Set startingCornerCell = selectedRange.Cells(1, 1)
19
20 Dim startingCellRow As Long
21 startingCellRow = startingCornerCell.Row
22 Dim startingCellColumn As Long
23 startingCellColumn = startingCornerCell.Column
24
25 Dim outputRow As Long
26 Dim outputColumn As Long
27 outputRow = outputRange.Row
28 outputColumn = outputRange.Column
29
30 Dim targetCell As Range
31
32 'We check for the intersection to ensure we don't overwrite any of the
   original data
33 'There's probably a better way to do this than For Each
34 For Each targetCell In selectedRange
35     If Not Intersect(selectedRange, Cells(outputRow + targetCell.Column -
       startingCellColumn, outputColumn + targetCell.Row -
       startingCellRow)) Is Nothing Then
36         MsgBox "Your destination intersects with your data"
37         Exit Sub
38     End If
39 Next targetCell
40
41 For Each targetCell In selectedRange
```

```

42     ActiveSheet.Cells(outputRow + targetCell.Column - startingCellColumn,
        outputColumn + targetCell.Row - startingCellRow).Formula =
        targetCell.Formula
43     Next targetCell
44
45 errCancel:
46     Application.ScreenUpdating = True
47     Application.EnableEvents = True
48     Application.Calculation = xlCalculationAutomatic
49     Application.Calculate
50 End Sub

```

CreateConditionalsForFormatting.md

```

1 Public Sub CreateConditionalsForFormatting()
2
3     On Error GoTo errHandler
4     Dim inputRange As Range
5     Set inputRange = GetInputOrSelection("Select the range of cells to
        convert")
6     'add these in as powers of 3, starting at 1 = 10^0
7     Const ARRAY_MARKERS As String = " ,k,M,B,T,Q"
8     Dim arrMarkers As Variant
9     arrMarkers = Split(ARRAY_MARKERS, ",")
10
11     Dim i As Long
12     For i = UBound(arrMarkers) To 0 Step -1
13
14         With inputRange.FormatConditions.Add(xlCellValue, xlGreaterEqual, 10
            ^ (3 * i))
15             .NumberFormat = "0.0" & Application.WorksheetFunction.Rept(" ", i
                ) & " " & arrMarkers(i) & """"
16         End With
17
18     Next
19     Exit Sub
20 errHandler:
21     MsgBox "No Range Selected!"

```

22 End Sub

ExtendArrayFormulaDown.md

```
1 Public Sub ExtendArrayFormulaDown()  
2  
3     Dim startingRange As Range  
4     Dim targetArea As Range  
5  
6  
7     Application.ScreenUpdating = False  
8  
9     Set startingRange = Selection  
10  
11     For Each targetArea In startingRange.Areas  
12  
13         Dim targetCell As Range  
14         For Each targetCell In targetArea.Cells  
15  
16             If targetCell.HasArray Then  
17  
18                 Dim formulaString As String  
19                 formulaString = targetCell.FormulaArray  
20  
21                 Dim startOfArray As Range  
22                 Dim endOfArray As Range  
23  
24                 Set startOfArray = targetCell.CurrentArray.Cells(1, 1)  
25                 Set endOfArray = startOfArray.Offset(0, -1).End(xlDown).  
26                     Offset(0, 1)  
27  
28                 targetCell.CurrentArray.Formula = vbNullString  
29  
30                 Range(startOfArray, endOfArray).FormulaArray = formulaString  
31             End If  
32  
33         Next targetCell
```

```
34     Next targetArea
35
36
37     'Find the range of the new array formula
38     'Save current formula and clear it out
39     'Apply the formula to the new range
40     Application.ScreenUpdating = True
41 End Sub
```

MakeHyperlinks.md

```
1 Public Sub MakeHyperlinks()
2
3     '+Changed to inputbox
4     On Error GoTo errorHandler
5     Dim targetRange As Range
6     Set targetRange = GetInputOrSelection("Select the range of cells to
       convert to hyperlink")
7
8     'TODO: choose a better variable name
9     Dim targetCell As Range
10    For Each targetCell In targetRange
11        ActiveSheet.Hyperlinks.Add Anchor:=targetCell, Address:=targetCell
12    Next targetCell
13    Exit Sub
14 errorHandler:
15    MsgBox "No Range Selected!"
16 End Sub
```

OutputColors.md

```
1 Public Sub OutputColors()
2
3     Const MINIMUM_INTEGER As Long = 1
4     Const MAXIMUM_INTEGER As Long = 10
5     Dim i As Long
```

```
6     For i = MINIMUM_INTEGER To MAXIMUM_INTEGER
7         ActiveCell.Offset(i).Interior.Color = Chart_GetColor(i)
8     Next i
9
10 End Sub
```

SelectedToValue.md

```
1 Public Sub SelectedToValue()
2
3     Dim targetRange As Range
4     On Error GoTo errHandler
5     Set targetRange = GetInputOrSelection("Select the formulas you'd like to
        convert to static values")
6
7     Dim targetCell As Range
8     Dim targetCellValue As String
9     For Each targetCell In targetRange
10         targetCellValue = targetCell.Value
11         targetCell.Clear
12         targetCell = targetCellValue
13     Next targetCell
14     Exit Sub
15 errHandler:
16     MsgBox "No selection made!"
17 End Sub
```

Selection_ColorWithHex.md

```
1 Public Sub Selection_ColorWithHex()
2
3     Dim targetCell As Range
4     Dim targetRange As Range
5     On Error GoTo errHandler
6     Set targetRange = GetInputOrSelection("Select the range of cells to color
        ")
```

```

7   For Each targetCell In targetRange
8       targetCell.Interior.Color = RGB( _
9           WorksheetFunction.Hex2Dec(Mid(targetCell.
10              Value, 2, 2)), _
11              WorksheetFunction.Hex2Dec(Mid(targetCell.
12              Value, 4, 2)), _
13              WorksheetFunction.Hex2Dec(Mid(targetCell.
14              Value, 6, 2)))
15
16 Next targetCell
17 Exit Sub
18
19 errHandler:
20     MsgBox "No selection made!"
21 End Sub

```

SplitAndKeep.md

```

1 Public Sub SplitAndKeep()
2
3     On Error GoTo SplitAndKeep_Error
4
5     Dim rangeToSplit As Range
6     Set rangeToSplit = GetInputOrSelection("Select range to split")
7
8     If rangeToSplit Is Nothing Then
9         Exit Sub
10    End If
11
12    Dim delimiter As Variant
13    delimiter = InputBox("What delimiter to split on?")
14    'StrPtr is undocumented, perhaps add documentation or change function
15    If StrPtr(delimiter) = 0 Then
16        Exit Sub
17    End If
18
19    Dim itemToKeep As Variant
20    'Perhaps inform user to input the sequence number of the item to keep
21    itemToKeep = InputBox("Which item to keep? (This is 0-indexed)")

```

```
22
23     If StrPtr(itemToKeep) = 0 Then
24         Exit Sub
25     End If
26
27     Dim targetCell As Range
28     For Each targetCell In Intersect(rangeToSplit, rangeToSplit.Parent.
        UsedRange)
29
30         Dim delimitedCellParts As Variant
31         delimitedCellParts = Split(targetCell, delimiter)
32
33         If UBound(delimitedCellParts) >= itemToKeep Then
34             targetCell.Value = delimitedCellParts(itemToKeep)
35         End If
36
37     Next targetCell
38
39     On Error GoTo 0
40     Exit Sub
41
42 SplitAndKeep_Error:
43     MsgBox "Check that a valid Range is selected and that a number was
        entered for which item to keep."
44 End Sub
```

SplitIntoColumns.md

```
1 Public Sub SplitIntoColumns()
2
3     Dim inputRange As Range
4
5     Set inputRange = GetInputOrSelection("Select the range of cells to split"
        )
6
7     Dim targetCell As Range
8
9     Dim delimiter As String
```

```

10     delimiter = Application.InputBox("What is the delimiter?", , ",",
    vbOKCancel)
11     If delimiter = "" Or delimiter = "False" Then GoTo errHandler
12     For Each targetCell In inputRange
13
14         Dim targetCellParts As Variant
15         targetCellParts = Split(targetCell, delimiter)
16
17         Dim targetPart As Variant
18         For Each targetPart In targetCellParts
19
20             Set targetCell = targetCell.Offset(, 1)
21             targetCell = targetPart
22
23         Next targetPart
24
25     Next targetCell
26     Exit Sub
27 errHandler:
28     MsgBox "No Delimiter Defined!"
29 End Sub

```

SplitIntoRows.md

```

1 Public Sub SplitIntoRows()
2
3     Dim outputRange As Range
4
5     Dim inputRange As Range
6     Set inputRange = Selection
7
8     Set outputRange = GetInputOrSelection("Select the output corner")
9
10    Dim targetPart As Variant
11    Dim offsetCounter As Long
12    offsetCounter = 0
13    Dim targetCell As Range
14

```

```
15     For Each targetCell In inputRange.SpecialCells(xlCellTypeVisible)
16         Dim targetParts As Variant
17         targetParts = Split(targetCell, vbLf)
18
19         For Each targetPart In targetParts
20             outputRange.Offset(offsetCounter) = targetPart
21
22             offsetCounter = offsetCounter + 1
23         Next targetPart
24     Next targetCell
25 End Sub
```

TrimSelection.md

```
1 Public Sub TrimSelection()
2
3     Dim rangeToTrim As Range
4     On Error GoTo errHandler
5     Set rangeToTrim = GetInputOrSelection("Select the formulas you'd like to
6         convert to static values")
7
8     'disable calcs to speed up
9     Application.ScreenUpdating = False
10    Application.EnableEvents = False
11    Application.Calculation = xlCalculationManual
12
13    'force to only consider used range
14    Set rangeToTrim = Intersect(rangeToTrim, rangeToTrim.Parent.UsedRange)
15
16    Dim targetCell As Range
17    For Each targetCell In rangeToTrim
18
19        'only change if needed
20        Dim temporaryTrimHolder As Variant
21        temporaryTrimHolder = Trim(targetCell.Value)
22
23        'added support for char 160
24        'TODO add more characters to remove
```

```
24     temporaryTrimHolder = Replace(temporaryTrimHolder, chr(160),  
25         vbNullString)  
26     If temporaryTrimHolder <> targetCell.Value Then targetCell.Value =  
27         temporaryTrimHolder  
28 Next targetCell  
29  
30 Application.Calculation = xlCalculationAutomatic  
31 Application.EnableEvents = True  
32 Application.ScreenUpdating = True  
33  
34 Exit Sub  
35 errorHandler:  
36 MsgBox "No Delimiter Defined!"  
37 Application.ScreenUpdating = False  
38 Application.EnableEvents = False  
39 Application.Calculation = xlCalculationManual  
40 End Sub
```

overview of 3 charting

Charting will be a major chapter in this book since it's the focus of a lot of what I do. It also is a spot where a significant amount of time can be saved since the chart options are awful to mess with.

Some high level topics:

- Creating a chart
- Formatting a chart
- Manipulating the series on a chart
- Changing the layout of charts on a page (make grid code)
- Common patterns when working through charts ([ForEach](#) loops wherever possible)

introduction to charting

Charting is the second most important aspect of automatic Excel behind manipulating [Ranges](#). There is a bias when saying that because a lot of what I do after engineering calculations is chart the results.

In particular, Excel can be used to great effect to chart time series of data. The other reason charts are so amenable to VBA is that very often you are applying the same actions to the charts. In that sense, the VBA related to charts is doing a lot of changing settings and formats so that the charts look the way you want. This has the immediate effect of making your charts look less like “they came from Excel” which is a common knock in some circles.

When working with **Charts**, there is a **Range** of difficulties depending on what you are trying to do. In some cases, working with an existing **chart** is much easier than creating a new one. In other instances, it can be much simpler to create a new chart rather, starting from a default, rather than change all the settings back. One other major difference between **Charts** and **Ranges** is that working with charts is much more about knowing the object model than knowing how to program. The vast majority of your code related to charts is simple iterating through objects to find the one property that you want to change. This makes it easier to write chart VBA once you have the basics of **For Each** loops down. It also means that you need to spend some time getting comfortable with the object model.

There is one oddity related to Charts that is worth mentioning now. Charts can either be embedded as an object on a **Worksheet**, or they can be their own **Sheets**. I personally never use the latter case, but it is common enough that it needs to be on your mind when working with Charting code.

(I don't use the Chart as a Sheet model because I find that it is not necessary in terms of displaying data. In particular, you are at the mercy of your window size and cannot easily change the dimensions. Also, it complicates the VBA side of things to work in both formats all the time, so I just decided to always put my Charts on Sheets. Your mileage may vary so I'll touch on both approaches in the code samples.)

a quick overview of the object model

- ChartObjects -> ChartObject - this derives from **Shape** and exists when the Chart is on a Worksheet
 - Chart
 - * SeriesCollection -> Series
 - * Axes -> Axis
 - * ChartArea
 - * PlotArea
- ActiveChart -> Chart - this works whether you have a Worksheet or Chart on a sheet
- Selection -> Variant - this one can be useful but is often not of the type that you want.

obtaining a reference to a Chart

When working with CHarts, the first task is typically to get a reference to an existing chart – unless you are creating a new chart. To obtain a reference to a chart, there are a handful of ways of doing it depending on what your spreadsheet contains and how it's structured.

The main ways to do it are:

- Use the `ActiveChart` object
- Use the `Selection` object – this is highly depending on what is selected
- Use the `ChartObjects` object
 - If you know which chart you want, you can supply an index; this works great if there is only a single chart - `ChartObjects(1)`
 - If you want to do something to all charts, you can iterate this object
 - If you have named the chart (more on that later) you can supply the name as the index - `ChartObjects("SomeChart")`
- The `Workbook.Sheets` object if your charts are contained in their own sheets
 - Same as above, you can access via a numeric index, name, or iterate through all of them

ActiveChart `ActiveChart` is similar to the other `Active` objects in that it does about what you expect. The one difference is that the Chart actually has to be selected or have focus in order to be considered “active”. This is similar but also different to something like `ActiveWorkbook` where having the workbook open makes it active.

Note that `ActiveChart` will work for a Chart that is contained on a Worksheet or also for one that is its own Sheet. If the latter case, then `ActiveSheet` and `ActiveChart` will refer to the same object. Side note: this technicality is why you will not get proper Intellisense when using `ActiveSheet` – that Sheet could technically be a Chart.

The nice thing about `ActiveChart` is that it gives you the Chart object which then gives you immediate access to the Chart related details you are like to want to change. The downside is that unless you have a single Chart that is already selected, `ActiveChart` has limited application when using VBA. Again, the goal is to avoid selecting objects in order to access them via VBA so `ActiveChart` has this limitation.

Selection The `Selection` object is probably the greatest catch all for an object. It literally holds anything, and this means that using the object requires knowing what is selected, or checking vigorously before using the object. Technically, you also let your code error out if the wrong object is selected, and

this works well at times. This works well because you are unlikely to be using Selection in a complicated workflow because, again, you should not be selecting objects to access them. This means that Selection is really limited to one-off and helper code where you can more tightly dictate that this code only works if you select a Chart. You should still add some error handling, but sometimes that step is skipped.

Since the Selection can hold anything, it's important to know what could be Selected. Related to charts, the following can all live in the Selection:

- ChartObjects
- Chart
- ChartArea
- PlotArea
- Legend
- ChartTitle
- Series

If you are writing VBA to work on Charts, you can technically require the user to select the correct part of the chart and always use [Selection](#). You will quickly grow tired of having to remember which part of the Chart to select in order to make the code work. To avoid this scenario, it is helpful to remember the object model and know how to work your way around a Chart.

My approach has always been to convert the Selection to a Collection of ChartObjects. I can then always iterate that resulting Collection to process the Charts. If only a single Chart was selected, the code works all the same. The downside to this approach is that a Chart as a Sheet cannot live inside a ChartObject. This is a large part of why I always put Charts on a Worksheet.

Below is the helper function I use in order to convert a possibly Chart containing selection into a Collection of ChartObjects. It works for all objects except for the Axis related ones.

TODO: consider improving this code if it is included as a de facto reference

```
1 Public Function Chart_GetObjectsFromObject(ByVal inputObject As Object) As
   Variant
2
3     Dim chartObjectCollection As New Collection
4
5     'NOTE that this function does not work well with Axis objects. Excel
       does not return the correct Parent for them.
6
7     Dim targetObject As Variant
```



```
8 Dim inputObjectType As String
9 inputObjectType = TypeName(inputObject)
10
11 Select Case inputObjectType
12
13     Case "DrawingObjects"
14         'this means that multiple charts are selected
15         For Each targetObject In inputObject
16             If TypeName(targetObject) = "ChartObject" Then
17                 'add it to the set
18                 chartObjectCollection.Add targetObject
19             End If
20         Next targetObject
21
22     Case "Worksheet"
23         For Each targetObject In inputObject.ChartObjects
24             chartObjectCollection.Add targetObject
25         Next targetObject
26
27     Case "Chart"
28         chartObjectCollection.Add inputObject.Parent
29
30     Case "ChartArea", "PlotArea", "Legend", "ChartTitle"
31         'parent is the chart, parent of that is the chart targetObject
32         chartObjectCollection.Add inputObject.Parent.Parent
33
34     Case "Series"
35         'need to go up three levels
36         chartObjectCollection.Add inputObject.Parent.Parent.Parent
37
38     Case "Axis", "Gridlines", "AxisTitle"
39         'these are the oddly unsupported objects
40         MsgBox "Axis/gridline selection not supported. This is an Excel
41             bug. Select another element on the chart(s)."
42
43     Case Else
44         MsgBox "Select a part of the chart(s), except an axis."
45 End Select
```

```
46
47     Set Chart_GetObjectsFromObject = chartObjectCollection
48 End Function
```

ChartObjects If you are working on a Worksheet, then that Worksheet will have the ChartObjects object. This object is great because it contains all of the Charts in their own collection (separate from any other Shapes or buttons). This ChartObjects collection contains object of type ChartObject. The ChartObject derives from Shape which means it contains all of the properties related to on-sheet position and size.

A typical workflow is included below since it is a pattern that shows up all the time in VBA code related to charts. At a high level the steps are:

- Use ActiveSheet or a Worksheet reference to access the ChartObjects
- Iterate through each ChartObject, storing a reference to the underlying Chart
- You then setup sections to work through the parts of the Chart you want
 - Iterate through the SeriesCollection
 - Iterate through the Axes
 - Touch the other top level properties including ChartTitle, Legend, etc.

This workflow is quite powerful because it can quickly be wrapped with a loop to go through all Worksheets and even possible all Workbooks. It's also powerful because you can be quite comfortable learning this pattern and then adding in the parts that you actually want to change. The only downside is that it can be quite tedious to type out all the loops every time, but there's not a good way around that other than to use the clipboard.

Another approach to using ChartObjects is to not iterate through all of them but instead to select a single ChartObject and work with it. There are two ways to do this:

- Use an integer index for the Chart – this is quite easy to do if there are only a few charts
- Name the chart and use that name

When using either of these approaches, it is quite helpful to show the **Selection Pane** window in Excel. This pane will pop out and tell you the order and the names of all the objects on the sheet (this includes comments, shapes, and Charts). From this pane, you can rearrange the charts into the order you want or rename them.

Although **For Each** loops are generally preferred when working with Charts, sometimes you simply know that you want to change one chart and an index just lets you do that. If you are in the habit of using loops

however, you can easily do that with the helper code included above which stick a single chart into a Collection.

Workbook.Sheets to get Chart references The final approach to obtaining a Chart reference is to use the Sheets object. Aside from ActiveChart, this is the only way to deal with Charts that are their own Sheet. Again, you can either use an index or a Name. Here, the Name is easily changed on the Sheet tab so it's much more common to use a Name when doing this. The other approach is to iterate through all the Sheets and pick off the ones that are Charts.

There are two key points when working with Charts as Sheets:

- You must use the Workbook.Sheets object to access them and not Workbook.Worksheets. The latter object contains only those Worksheets that are not Charts. The former contains both Charts and Worksheets.
- It's possible that your Sheet is not actually a Chart. You should check the type of the object is you are going to iterate through all Worksheets. Also be aware that some sheets can be hidden which might lead to unexpected results.

TODO: is there a Charts object on Workbook?

common objects/properties for a Chart

This section will focus on the common formatting changes that can be made to a Chart. the next section focuses on creating a Chart from scratch if you want to see that. These common changes will be grouped by the type that they affect, but this is not meant to be an exhaustive list. Instead, this is a list that will cover the objects and functions that are actually used in regular code. There will be several other things that you will need to check the reference for (or record a macro), but this listing will get you started with the regular things.

To organize this section, we will focus on the different parts of a Chart in turn along with how to access the things you need. This section is meant to be a one stop shop for working on the common parts of a Chart. This will cover:

- ChartObject
 - Top, Left, Height, Width - control the location of a chart
- Chart
 - ChartType

-
- Access the other objects and controls whether some things exist
 - * HasLegend
 - * HasTitle
 - Legend
 - Series – accessed the the Chart.SeriesCollection
 - ChartType
 - Axis – accessed through Chart.Axes
 - Display the axis
 - Change the text
 - Change the min/max scale including automatic values
 - Change the number format of the axis
 - Change the format and display of the Gridlines
 - Point – accessed through a Series
 - Change display of individual points
 - Control the DataLabels (HasLabel and then DataLabel)
 - Trendline

TODO: go through BUTL and find other commonly appearing things

common changes to the ChartObject

The ChartObject is the main container for a Chart that is on a Worksheet. The common changes then are related to the position and size of the Chart on the Worksheet. The common properties to change here are:

- Top
- Left
- Height
- Width
- Placement (controls the move with cells option)

All of these are of type Double which means you can use decimal calculations to determine the size or position. In Excel, the 0,0 point is at the upper left hand corner (upper left of cell A1) and the Top and Left increase going to the right and down. If you are familiar with 0,0 being the center of the XY plane, then Excel will be a tad unfamiliar. Once you get used to it, you will realize that there is not really a better way to arrange the coordinate system since the spreadsheet can extend to the right and down nearly infinitely.

TODO: are there Bottom and Right properties too? TODO: add a comment about Points vs. inches here and

the function to convert them

The most common application of changing these properties is to either standardize the size of several charts or to arrange the charts in a grid (which standardizes the size and then position).

That code is included below:

TODO: clean up this code to only the required parts

```
1 Public Sub Chart_GridOfCharts( _
2     Optional columnCount As Long = 3, _
3     Optional chartWidth As Double = 400, _
4     Optional chartHeight As Double = 300, _
5     Optional offsetVertical As Double = 80, _
6     Optional offsetHorizontal As Double = 40, _
7     Optional shouldFillDownFirst As Boolean = False, _
8     Optional shouldZoomOnGrid As Boolean = False)
9
10    Dim targetObject As ChartObject
11
12    Dim targetSheet As Worksheet
13    Set targetSheet = ActiveSheet
14
15    Application.ScreenUpdating = False
16
17    Dim countOfCharts As Long
18    countOfCharts = 0
19
20    For Each targetObject In targetSheet.ChartObjects
21        Dim left As Double, top As Double
22
23        If shouldFillDownFirst Then
24            left = (countOfCharts \ columnCount) * chartWidth +
25                offsetHorizontal
26            top = (countOfCharts Mod columnCount) * chartHeight +
27                offsetVertical
28        Else
29            left = (countOfCharts Mod columnCount) * chartWidth +
30                offsetHorizontal
31            top = (countOfCharts \ columnCount) * chartHeight +
32                offsetVertical
```

```

29         End If
30
31         targetObject.top = top
32         targetObject.left = left
33         targetObject.Width = chartWidth
34         targetObject.Height = chartHeight
35
36         countOfCharts = countOfCharts + 1
37
38     Next targetObject
39
40     'loop through columns to find how far to zoom
41     'Cells.Left property returns a variant in points
42     If shouldZoomOnGrid Then
43         Dim columnToZoomTo As Long
44         columnToZoomTo = 1
45         Do While targetSheet.Cells(1, columnToZoomTo).left < columnCount *
            chartWidth
46             columnToZoomTo = columnToZoomTo + 1
47         Loop
48
49         targetSheet.Range("A:A", targetSheet.Cells(1, columnToZoomTo - 1).
            EntireColumn).Select
50         ActiveWindow.Zoom = True
51         targetSheet.Range("A1").Select
52     End If
53
54     Application.ScreenUpdating = True
55
56 End Sub

```

common properties of the Chart

The Chart object is mostly a container for the other more useful properties of the Chart, but there are a couple of common properties that live at this top level. Those include:

- The HasXXX: HasTitle, HasLegend (TODO: any others?) - control the display of these things
- ChartType

-
- Delete
 - Copy (TODO: this on ChartObject also?)

TODO: find more of these

In addition to those properties, the Chart object provides access to other useful things via the common accessors:

- SeriesCollection
- Axes
- Legend
- ChartTitle
- ChartArea
- PlotArea

TODO: is this list complete?

common properties of the Series

One of the two most used Chart objects is the Series (other is the Axis). The Series ends up being powerful because it provides access to the data of the Chart along with the major formatting choices since the Series is the prominent feature of a Chart.

The common things to go after for a series are:

- Data related
 - Name
 - XValues
 - Values
 - Formula
- Formatting related
 - Format
 - * Line
 - MarkerSize
 - MarkerStyle
 - MarkerForegroundColor, MarkerBackgroundColor

Also, from a Series you can access the following other objects:

- Points

-
- Trendlines

common properties of the Axis

The Axis is the second most common object to work with (behind the Series). This is largely because the Axis controls or provides access to a lot of the formatting related aspects of the CHart. The Axis also controls the scale of the Axis and in that regard, is a critical part of making or editing a Chart.

The first part of the Axis is accessing the correct one. This is slightly tricky the first time because the Axes are stored in the Chart.Axes object. The real trick is that this object is indexed by the xlAxisType (TODO: check that) which can be xlCategory (for the x-axis) or xlValue/xlValue2 (for the y-axis, left and right).

Once you have an Axis object, you can set to work changing the common properties:

- Scale related
 - MinimumScale/MaximumScale
 - MinimumScaleIsAuto/MaximumScaleIsAuto
- Formatting related (most of these are accessors to a different object)
 - GridLines (Major/minor and the HasXXX)
 - Ticks (TODO: that right?)
 - HasTitle and AxisTitle

Chart_Axis_AutoX.md

```
1 Public Sub Chart_Axis_AutoX()  
2  
3     Dim targetObject As ChartObject  
4     For Each targetObject In Chart_GetObjectsFromObject(Selection)  
5         Dim targetChart As Chart  
6         Set targetChart = targetObject.Chart  
7  
8         Dim xAxis As Axis  
9         Set xAxis = targetChart.Axes(xlCategory)  
10        xAxis.MaximumScaleIsAuto = True  
11        xAxis.MinimumScaleIsAuto = True  
12        xAxis.MajorUnitIsAuto = True  
13        xAxis.MinorUnitIsAuto = True  
14  
15    Next targetObject  
16
```

17 End Sub

Chart_Axis_AutoY.md

```
1 Public Sub Chart_Axis_AutoY()  
2  
3     Dim targetObject As ChartObject  
4     For Each targetObject In Chart_GetObjectsFromObject(Selection)  
5         Dim targetChart As Chart  
6         Set targetChart = targetObject.Chart  
7  
8         Dim yAxis As Axis  
9         Set yAxis = targetChart.Axes(xlValue)  
10        yAxis.MaximumScaleIsAuto = True  
11        yAxis.MinimumScaleIsAuto = True  
12        yAxis.MajorUnitIsAuto = True  
13        yAxis.MinorUnitIsAuto = True  
14  
15        Next targetObject  
16  
17 End Sub
```

Chart_AxisTitleIsSeriesTitle.md

```
1 Public Sub Chart_AxisTitleIsSeriesTitle()  
2  
3     Dim targetObject As ChartObject  
4     Dim targetChart As Chart  
5     For Each targetObject In Chart_GetObjectsFromObject(Selection)  
6         Set targetChart = targetObject.Chart  
7  
8         Dim butlSeries As bUTLChartSeries  
9         Dim targetSeries As series  
10  
11        For Each targetSeries In targetChart.SeriesCollection  
12            Set butlSeries = New bUTLChartSeries  
13            butlSeries.UpdateFromChartSeries targetSeries  
14  
15            targetChart.Axes(xlValue, targetSeries.AxisGroup).HasTitle = True
```

```

16         targetChart.Axes(xlValue, targetSeries.AxisGroup).AxisTitle.Text
           = butlSeries.name
17
18         '2015 11 11, adds the x-title assuming that the name is one cell
           above the data
19         '2015 12 14, add a check to ensure that the XValue exists
20         If Not butlSeries.XValues Is Nothing Then
21             targetChart.Axes(xlCategory).HasTitle = True
22             targetChart.Axes(xlCategory).AxisTitle.Text = butlSeries.
               XValues.Cells(1, 1).Offset(-1).Value
23         End If
24
25     Next targetSeries
26 Next targetObject
27 End Sub

```

Chart_FitAxisToMaxAndMin.md

```

1 Public Sub Chart_FitAxisToMaxAndMin(ByVal axisType As XlAxisType)
2
3     Dim targetObject As ChartObject
4     For Each targetObject In Chart_GetObjectsFromObject(Selection)
5         '2015 11 09 moved first inside loop so that it works for multiple
           charts
6         Dim isFirst As Boolean
7         isFirst = True
8
9         Dim targetChart As Chart
10        Set targetChart = targetObject.Chart
11
12        Dim targetSeries As series
13        For Each targetSeries In targetChart.SeriesCollection
14
15            Dim minSeriesValue As Double
16            Dim maxSeriesValue As Double
17
18            If axisType = xlCategory Then
19
20                minSeriesValue = Application.Min(targetSeries.XValues)
21                maxSeriesValue = Application.Max(targetSeries.XValues)

```

```

22
23     ElseIf axisType = xlValue Then
24
25         minSeriesValue = Application.Min(targetSeries.Values)
26         maxSeriesValue = Application.Max(targetSeries.Values)
27
28     End If
29
30     Dim targetAxis As Axis
31     Set targetAxis = targetChart.Axes(axisType)
32
33     Dim isNewMax As Boolean, isNewMin As Boolean
34     isNewMax = maxSeriesValue > targetAxis.MaximumScale
35     isNewMin = minSeriesValue < targetAxis.MinimumScale
36
37     If isFirst Or isNewMin Then targetAxis.MinimumScale =
38         minSeriesValue
39     If isFirst Or isNewMax Then targetAxis.MaximumScale =
40         maxSeriesValue
41
42     isFirst = False
43     Next targetSeries
44 Next targetObject
End Sub

```

Chart_YAxisRangeWithAvgAndStdev.md

```

1 Public Sub Chart_YAxisRangeWithAvgAndStdev()
2
3     Dim numberOfStdDevs As Double
4
5     numberOfStdDevs = CDbI(InputBox("How many standard deviations to include?
6         "))
7
8     Dim targetObject As ChartObject
9
10    For Each targetObject In Chart_GetObjectsFromObject(Selection)
11
12        Dim targetSeries As series

```

```
12     Set targetSeries = targetObject.Chart.SeriesCollection(1)
13
14     Dim avgSeriesValue As Double
15     Dim stdSeriesValue As Double
16
17     avgSeriesValue = WorksheetFunction.Average(targetSeries.Values)
18     stdSeriesValue = WorksheetFunction.StDev(targetSeries.Values)
19
20     targetObject.Chart.Axes(xlValue).MinimumScale = avgSeriesValue -
        stdSeriesValue * numberOfStdDevs
21     targetObject.Chart.Axes(xlValue).MaximumScale = avgSeriesValue +
        stdSeriesValue * numberOfStdDevs
22
23     Next
24
25 End Sub
```

common properties of the Legend

The Legend is a simple affair compared to the others. There really only two things to do with it: remove it or move it. Both of these are simple enough:

- HasLegend (on the Chart)
- Delete
- Position

TODO: add an example of these in action

common properties of a Point

The Point represents the lowest level when it comes to how the data and formatting of a Chart is built. In general, you do not have to actively go editing Points. This is because you will typically edit the appearance of the Series and the Axes to get the Chart that you want. There are however times when you get down to the metal and edit the properties of the individual points. Before describing how to do this, it may help to give an example or two for why you want to get down to this level:

- Delete a data point without touching the Series

-
- Add a DataLabel to the point if the value is below some threshold (or if some other Range has a value)
 - Hide a Point from one series because you want it to show up in another one

Of the tasks above, only one of them (the second) has to be accomplished via the Points. The others *could* be done via a different method, but you might find yourself in a spot where iterating some Points will save a ton of headache elsewhere. A cautionary note is that typically you should not be editing the properties of a Point; there is nearly always a better way to do these things. Part of the problem is that the settings you change will be quickly overwritten by changes in Excel or VBA. If you know you just need something done however, Points can be a quick way to make it happen.

TODO: look into ErrorBars here?

When thinking about working through the Points of a Series, consider the common properties you can change:

- HasLabel / DataLabel
- Value
- Formatting? (TODO: what are these)
- Hidden

TODO: finish this list

Note that in addition to the common properties, you can also change anything that can be changed from the normal Excel settings/properties window.

common properties of the TrendLine

The TrendLine is one of the lesser used properties, but it can be a real time saver when using VBA if you need to. The problem with the trendline normally is that you are required to work through a ton of menus to configure the properties. This is even more painful when you've got to do the same thing to multiple Series in a Chart or across multiple Charts. Similar to the other objects here, you can use VBA to quickly do the task that is otherwise a pain.

The most likely properties you'll use:

- Creating one off of a series
- Type
- Parameter

TODO: confirm these are correct TODO: add an example showing how to add a Trendline for every Series

Chart_AddTrendlineToSeriesAndColor.md

```
1 Public Sub Chart_AddTrendlineToSeriesAndColor()
2
3     Dim targetObject As ChartObject
4
5     For Each targetObject In Chart_GetObjectsFromObject(Selection)
6         Dim chartIndex As Long
7         chartIndex = 1
8
9         Dim targetSeries As series
10        For Each targetSeries In targetObject.Chart.SeriesCollection
11
12            Dim butlSeries As New bUTLChartSeries
13            butlSeries.UpdateFromChartSeries targetSeries
14
15            'clear out old ones
16            Dim j As Long
17            For j = 1 To targetSeries.Trendlines.Count
18                targetSeries.Trendlines(j).Delete
19            Next j
20
21            targetSeries.MarkerBackgroundColor = Chart_GetColor(chartIndex)
22
23            Dim newTrendline As Trendline
24            Set newTrendline = targetSeries.Trendlines.Add()
25            newTrendline.Type = xlLinear
26            newTrendline.Border.Color = targetSeries.MarkerBackgroundColor
27
28            '2015 11 06 test to avoid error without name
29            '2015 12 07 dealing with multi-cell Names
30            'TODO: handle if the name is not a range also
31            If Not butlSeries.name Is Nothing Then
32                newTrendline.name = butlSeries.name.Cells(1, 1).Value
33            End If
34
35            newTrendline.DisplayEquation = True
36            newTrendline.DisplayRSquared = True
37            newTrendline.DataLabel.Format.TextFrame2.TextRange.Font.Fill.
                ForeColor.RGB = Chart_GetColor(chartIndex)
```

```
38
39         chartIndex = chartIndex + 1
40     Next targetSeries
41
42     Next targetObject
43 End Sub
```

creating charts from scratch

The previous section discussed how to work with existing Charts. This section will focus on how to create those Charts from scratch if you are coming into a blank Worksheet or if you simply need to add a chart to existing data. At the start, it's worth mentioning that creating Charts from scratch falls into one of two categories:

- Library/helper type code where you want to quickly create a Chart in a common way. This type of code works best in an addin and typically provides functionality that you wish Excel had from the start
- One-off code for a specific application. This involves creating a Chart with some sort of odd manipulation or formatting or other detail where automation saves time.

The two types of category will end up with code that looks similar, but the goals of the former category will be slightly different than the latter. Typically when making code for a one-off application, you can make more assumptions about how the data is structured and what sorts of actions need to be taken. When working with helper code, you will spend more time asking for user input, and handling the different cases that might come up.

Another key point to make is that the type of work that is being done in a chart can vary as well. The splitting line here is whether the Chart creation is data heavy or formatting heavy (or possibly both). For a data heavy Chart, you will spend a lot of time collecting Ranges, creating Series, and possibly manipulating individual Points. For a formatting heavy chart, you will spend a lot of time iterating through the Series to apply formatting, label the Axes, set the number formats, and generally modify the Excel defaults. Both of these tasks are very time intensive if you are doing them without VBA, so both lend themselves to being automated if possible.

Excel provides two means of creating a Chart depending on how you want to handle things. Those two commands are:

- ChartObjects.Add

-
- TODO: what is the other method

I always prefer to use `ChartObjects.Add` because of its consistent application. The other approach tends to put you at the mercy of how Excel interprets your data and its layout.

TODO: add more detail here

The general process for creating a chart looks like this:

- Create a new `ChartObject` via `ChartObjects.Add` - store that reference
 - If you know where you want the Chart to go, you can use that information here
- Access the Chart of that object
- Change the properties of the Chart that you know – namely `ChartType`
- Access the `SeriesCollection` of the Chart and call `NewSeries` for each Series you want - store a reference to that Series
 - This is typically done inside a loop that is iterating through Ranges in some way
 - If you need to apply Series specific formatting, do that here
- Access the Axes collection and modify any specific parts of the Axes that you want
 - This may show up in the loop above if you want the Axis to draw information from the Series (maybe set the max to the max of the data?)

At this point, you will have a Chart with the Series you want along with the major formatting taken care of. Even better, this general framework lends itself nicely to adding new commands where needed. If you need to go after some of the finer details of the Chart, you can add those commands where the objects are being reference, or at the end of the code. The main thing to consider is whether you need to work inside loops (per Series) or if you can process the extra stuff at the end.

The other upside of this approach is that you can quickly wrap all of this code with another loop to create multiple Charts. You can then wrap that code with another loop to do it on multiple Worksheets, etc. When you write code that can cleanly live inside a loop, you make it easy to use the code elsewhere.

One other aspect of Charts that is somewhat unique is that you can typically reuse a lot of the code by creating new Subs. These can be called from the inside of a loop to create a chain of commands to process a Chart. This approach is highly effective if you work in an environment where the same or similar things need to be done. For example: you have a monthly report to create each month for multiple departments. Standardizing as much of that work into modules makes it easy to apply the code in multiple spots with minor changes. This is relevant to Charts because most of the work of Charts is changing the values of specific properties. There is typically far less logic that is unique to an application (like trying to build a Range based on the layout of data).

Once you have this general framework mastered, you can quickly use it to make more charts.

TODO: add some examples of creating Charts

specific charting examples

This section will focus on some specific applications of applying VBA to charts. The code here can be quickly reused for your own application. These examples include:

- Creating a grid of XY scatter plots (a scatter matrix) based on a block of data
- Creating a panel of time series, one chart per each value with a common x-axis

TODO: identify the examples to include here

creating an XY scatter matrix

ChartCreateXYGrid.md

```
1 Public Sub ChartCreateXYGrid()  
2  
3     On Error GoTo ChartCreateXYGrid_Error  
4  
5     DeleteAllCharts  
6     'VBA doesn't allow a constant to be defined using a function (rgb) so we  
7     use a local variable rather than  
8     'muddying it up with the calculated value of the rgb function  
9     Dim majorGridlineColor As Long  
10    majorGridlineColor = RGB(200, 200, 200)  
11    Dim minorGridlineColor As Long  
12    minorGridlineColor = RGB(220, 220, 220)  
13  
14    Const CHART_HEIGHT As Long = 300  
15    Const CHART_WIDTH As Long = 400  
16    Const MARKER_SIZE As Long = 3  
17    'dataRange will contain the block of data with titles included  
18    Dim dataRange As Range  
19    Set dataRange = Application.InputBox("Select data with titles", Type:=8)  
20  
21    Application.ScreenUpdating = False  
22  
23    Dim rowIndex As Long, columnIndex As Long
```

```

23     rowIndex = 0
24
25     Dim xAxisDataRange As Range, yAxisDataRange As Range
26     For Each yAxisDataRange In dataRange.Columns
27         columnIndex = 0
28
29         For Each xAxisDataRange In dataRange.Columns
30             If rowIndex <> columnIndex Then
31                 Dim targetChart As Chart
32                 Set targetChart = ActiveSheet.ChartObjects.Add(columnIndex *
33                                                                                               rowIndex *
34                                                                                               CHART_HEIGHT
35                                                                                               + 100, _
36                                                                                               CHART_WIDTH,
37                                                                                               CHART_HEIGHT
38                                                                                               ).Chart
39
40                 Dim targetSeries As series
41                 Dim butlSeries As New bUTLChartSeries
42
43                 'offset allows for the title to be excluded
44                 Set butlSeries.XValues = Intersect(xAxisDataRange,
45                                                     xAxisDataRange.Offset(1))
46                 Set butlSeries.Values = Intersect(yAxisDataRange,
47                                                     yAxisDataRange.Offset(1))
48                 Set butlSeries.name = yAxisDataRange.Cells(1)
49                 butlSeries.ChartType = xlXYScatter
50
51                 Set targetSeries = butlSeries.AddSeriesToChart(targetChart)
52
53                 targetSeries.MarkerSize = MARKER_SIZE
54                 targetSeries.MarkerStyle = xlMarkerStyleCircle
55
56                 Dim targetAxis As Axis
57                 Set targetAxis = targetChart.Axes(xlCategory)
58                 targetAxis.HasTitle = True
59                 targetAxis.AxisTitle.Text = xAxisDataRange.Cells(1)
60                 targetAxis.MajorGridlines.Border.Color = majorGridlineColor

```

```

55         targetAxis.MinorGridlines.Border.Color = minorGridlineColor
56
57         Set targetAxis = targetChart.Axes(xlValue)
58         targetAxis.HasTitle = True
59         targetAxis.AxisTitle.Text = yAxisDataRange.Cells(1)
60         targetAxis.MajorGridlines.Border.Color = majorGridlineColor
61         targetAxis.MinorGridlines.Border.Color = minorGridlineColor
62
63         targetChart.HasTitle = True
64         targetChart.ChartTitle.Text = yAxisDataRange.Cells(1) & " vs.
        " & xAxisDataRange.Cells(1)
65         'targetChart.ChartTitle.Characters.Font.Size = 8
66         targetChart.Legend.Delete
67     End If
68
69     columnIndex = columnIndex + 1
70 Next xAxisDataRange
71
72     rowIndex = rowIndex + 1
73 Next yAxisDataRange
74
75 Application.ScreenUpdating = True
76
77 dataRange.Cells(1, 1).Activate
78
79 On Error GoTo 0
80 Exit Sub
81
82 ChartCreateXYGrid_Error:
83
84 MsgBox "Error " & Err.Number & " (" & Err.Description & _
85     ") in procedure ChartCreateXYGrid of Module Chart_Format"
86 MsgBox "This is most likely due to Range issues"
87
88 End Sub

```

creating a panel of time series plots

Chart_TimeSeries.md

```
1 Public Sub Chart_TimeSeries(ByVal rangeOfDates As Range, ByVal dataRange As
   Range, ByVal rangeOfTitles As Range)
2
3     Application.ScreenUpdating = False
4     Const MARKER_SIZE As Long = 3
5     Dim majorGridlineColor As Long
6     majorGridlineColor = RGB(200, 200, 200)
7     Dim chartIndex As Long
8     chartIndex = 1
9
10    Dim titleRange As Range
11    Dim targetColumn As Range
12
13    For Each titleRange In rangeOfTitles
14
15        Dim targetObject As ChartObject
16        Set targetObject = ActiveSheet.ChartObjects.Add(chartIndex * 300, 0,
            300, 300)
17
18        Dim targetChart As Chart
19        Set targetChart = targetObject.Chart
20        targetChart.ChartType = xlXYScatterLines
21        targetChart.HasTitle = True
22        targetChart.Legend.Delete
23
24        Dim targetAxis As Axis
25        Set targetAxis = targetChart.Axes(xlValue)
26        targetAxis.MajorGridlines.Border.Color = majorGridlineColor
27
28        Dim targetSeries As series
29        Dim butlSeries As New BUTLChartSeries
30
31        Set butlSeries.XValues = rangeOfDates
32        Set butlSeries.Values = dataRange.Columns(chartIndex)
33        Set butlSeries.name = titleRange
34
35        Set targetSeries = butlSeries.AddSeriesToChart(targetChart)
36
```

```
37     targetSeries.MarkerSize = MARKER_SIZE
38     targetSeries.MarkerStyle = xlMarkerStyleCircle
39
40     chartIndex = chartIndex + 1
41
42     Next titleRange
43
44     Application.ScreenUpdating = True
45 End Sub
```

applying common formatting to all Charts

ChartDefaultFormat.md

```
1 Public Sub ChartDefaultFormat()
2
3     Const MARKER_SIZE As Long = 3
4     Dim majorGridlineColor As Long
5     majorGridlineColor = RGB(242, 242, 242)
6     Const TITLE_FONT_SIZE As Long = 12
7     Const SERIES_LINE_WEIGHT As Single = 1.5
8
9     Dim targetObject As ChartObject
10
11     For Each targetObject In Chart_GetObjectsFromObject(Selection)
12         Dim targetChart As Chart
13
14         Set targetChart = targetObject.Chart
15
16         Dim targetSeries As series
17         For Each targetSeries In targetChart.SeriesCollection
18
19             targetSeries.MarkerSize = MARKER_SIZE
20             targetSeries.MarkerStyle = xlMarkerStyleCircle
21
22             If targetSeries.ChartType = xlXYScatterLines Then targetSeries.
                Format.Line.Weight = SERIES_LINE_WEIGHT
23
24             targetSeries.MarkerForegroundColorIndex = xlColorIndexNone
25             targetSeries.MarkerBackgroundColorIndex = xlColorIndexAutomatic
```

```

26
27     Next targetSeries
28
29
30     targetChart.HasLegend = True
31     targetChart.Legend.Position = xlLegendPositionBottom
32
33     Dim targetAxis As Axis
34     Set targetAxis = targetChart.Axes(xlValue)
35
36     targetAxis.MajorGridlines.Border.Color = majorGridlineColor
37     targetAxis.Crosses = xlAxisCrossesMinimum
38
39     Set targetAxis = targetChart.Axes(xlCategory)
40
41     targetAxis.HasMajorGridlines = True
42
43     targetAxis.MajorGridlines.Border.Color = majorGridlineColor
44
45     If targetChart.HasTitle Then
46         targetChart.ChartTitle.Characters.Font.Size = TITLE_FONT_SIZE
47         targetChart.ChartTitle.Characters.Font.Bold = True
48     End If
49
50     Set targetAxis = targetChart.Axes(xlCategory)
51
52     Next targetObject
53
54 End Sub

```

Chart_AddTitles.md

```

1 Public Sub Chart_AddTitles()
2
3     Dim targetObject As ChartObject
4     Const X_AXIS_TITLE As String = "x axis"
5     Const Y_AXIS_TITLE As String = "y axis"
6     Const SECOND_Y_AXIS_TITLE As String = "2nd y axis"

```

```

7      Const CHART_TITLE As String = "chart"
8
9      For Each targetObject In Chart_GetObjectsFromObject(Selection)
10         With targetObject.Chart
11             If Not .Axes(xlCategory).HasTitle Then
12                 .Axes(xlCategory).HasTitle = True
13                 .Axes(xlCategory).AxisTitle.Text = X_AXIS_TITLE
14             End If
15
16             If Not .Axes(xlValue, xlPrimary).HasTitle Then
17                 .Axes(xlValue).HasTitle = True
18                 .Axes(xlValue).AxisTitle.Text = Y_AXIS_TITLE
19             End If
20
21             '2015 12 14, add support for 2nd y axis
22             If .Axes.Count = 3 Then
23                 If Not .Axes(xlValue, xlSecondary).HasTitle Then
24                     .Axes(xlValue, xlSecondary).HasTitle = True
25                     .Axes(xlValue, xlSecondary).AxisTitle.Text =
26                         SECOND_Y_AXIS_TITLE
27                 End If
28             End If
29
30             If Not .HasTitle Then
31                 .HasTitle = True
32                 .ChartTitle.Text = CHART_TITLE
33             End If
34         End With
35     Next targetObject
36 End Sub

```

Chart_ApplyFormattingToSelected.md

```

1 Public Sub Chart_ApplyFormattingToSelected()
2
3     Dim targetObject As ChartObject
4     Const MARKER_SIZE As Long = 5

```

```
5
6     For Each targetObject In Chart_GetObjectsFromObject(Selection)
7
8         Dim targetSeries As series
9
10        For Each targetSeries In targetObject.Chart.SeriesCollection
11            targetSeries.MarkerSize = MARKER_SIZE
12        Next targetSeries
13    Next targetObject
14
15 End Sub
```

Chart_ApplyTrendColors.md

```
1 Public Sub Chart_ApplyTrendColors()
2
3     Dim targetObject As ChartObject
4     For Each targetObject In Chart_GetObjectsFromObject(Selection)
5
6         Dim targetSeries As series
7         For Each targetSeries In targetObject.Chart.SeriesCollection
8
9             Dim butlSeries As New bUTLChartSeries
10            butlSeries.UpdateFromChartSeries targetSeries
11
12            targetSeries.MarkerForegroundColorIndex = xlColorIndexNone
13            targetSeries.MarkerBackgroundColor = Chart_GetColor(butlSeries.
14                SeriesNumber)
15
16            targetSeries.Format.Line.ForeColor.RGB = targetSeries.
17                MarkerBackgroundColor
18        Next targetSeries
19    Next targetObject
20 End Sub
```

Chart_CreateChartWithSeriesForEachColumn.md

```
1 Public Sub Chart_CreateChartWithSeriesForEachColumn()  
2     'will create a chart that includes a series with no x value for each  
3     column  
4  
5     Dim dataRange As Range  
6     Set dataRange = GetInputOrSelection("Select chart data")  
7  
8     'create a chart  
9     Dim targetObject As ChartObject  
10    Set targetObject = ActiveSheet.ChartObjects.Add(0, 0, 300, 300)  
11  
12    targetObject.Chart.ChartType = xlXYScatter  
13  
14    Dim targetColumn As Range  
15    For Each targetColumn In dataRange.Columns  
16  
17        Dim chartDataRange As Range  
18        Set chartDataRange = RangeEnd(targetColumn.Cells(1, 1), xlDown)  
19  
20        Dim butlSeries As New bUTLChartSeries  
21        Set butlSeries.Values = chartDataRange  
22  
23        butlSeries.AddSeriesToChart targetObject.Chart  
24    Next targetColumn  
25 End Sub
```

Chart_CreateDataLabels.md

```
1 Public Sub Chart_CreateDataLabels()  
2  
3     Dim targetObject As ChartObject  
4     On Error GoTo Chart_CreateDataLabels_Error  
5  
6     For Each targetObject In Chart_GetObjectsFromObject(Selection)
```

```

7
8     Dim targetSeries As series
9     For Each targetSeries In targetObject.Chart.SeriesCollection
10
11         Dim dataPoint As Point
12         Set dataPoint = targetSeries.Points(2)
13
14         dataPoint.HasDataLabel = False
15         dataPoint.DataLabel.Position = xlLabelPositionRight
16         dataPoint.DataLabel.ShowSeriesName = True
17         dataPoint.DataLabel.ShowValue = False
18         dataPoint.DataLabel.ShowCategoryName = False
19         dataPoint.DataLabel.ShowLegendKey = True
20
21     Next targetSeries
22 Next targetObject
23
24 On Error GoTo 0
25 Exit Sub
26
27 Chart_CreateDataLabels_Error:
28
29     MsgBox "Error " & Err.Number & " (" & Err.Description & ") in procedure
30         Chart_CreateDataLabels of Module Chart_Format"
31 End Sub

```

Chart_ExtendSeriesToRanges.md

```

1 Public Sub Chart_ExtendSeriesToRanges()
2
3     Dim targetObject As ChartObject
4
5     For Each targetObject In Chart_GetObjectsFromObject(Selection)
6
7         Dim targetSeries As series
8
9         'get each series

```

```

10     For Each targetSeries In targetObject.Chart.SeriesCollection
11
12         'create the bUTL obj and manipulate series ranges
13         Dim butlSeries As New bUTLChartSeries
14         butlSeries.UpdateFromChartSeries targetSeries
15
16         If Not butlSeries.XValues Is Nothing Then
17             targetSeries.XValues = RangeEnd(butlSeries.XValues.Cells(1),
18                 xlDown)
19         End If
20         targetSeries.Values = RangeEnd(butlSeries.Values.Cells(1), xlDown
21             )
22     Next targetSeries
23 Next targetObject
24 End Sub

```

Chart_GoToXRange.md

```

1 Public Sub Chart_GoToXRange()
2
3
4     If TypeName(Selection) = "Series" Then
5         Dim b As New bUTLChartSeries
6         b.UpdateFromChartSeries Selection
7
8         b.XValues.Parent.Activate
9         b.XValues.Activate
10    Else
11        MsgBox "Select a series in order to use this."
12    End If
13
14 End Sub

```

Chart_SortSeriesByName.md

```

1 Public Sub Chart_SortSeriesByName()
2     'this will sort series by names
3     Dim targetObject As ChartObject
4     For Each targetObject In Chart_GetObjectsFromObject(Selection)
5
6         'uses a simple bubble sort but it works... shouldn't have 1000 series
          anyways
7         Dim firstChartIndex As Long
8         Dim secondChartIndex As Long
9         For firstChartIndex = 1 To targetObject.Chart.SeriesCollection.Count
10            For secondChartIndex = (firstChartIndex + 1) To targetObject.
              Chart.SeriesCollection.Count
11
12                Dim butlSeries1 As New bUTLChartSeries
13                Dim butlSeries2 As New bUTLChartSeries
14
15                butlSeries1.UpdateFromChartSeries targetObject.Chart.
                  SeriesCollection(firstChartIndex)
16                butlSeries2.UpdateFromChartSeries targetObject.Chart.
                  SeriesCollection(secondChartIndex)
17
18                If butlSeries1.name.Value > butlSeries2.name.Value Then
19                    Dim indexSeriesSwap As Long
20                    indexSeriesSwap = butlSeries2.SeriesNumber
21                    butlSeries2.SeriesNumber = butlSeries1.SeriesNumber
22                    butlSeries1.SeriesNumber = indexSeriesSwap
23                    butlSeries2.UpdateSeriesWithNewValues
24                    butlSeries1.UpdateSeriesWithNewValues
25                End If
26
27                Next secondChartIndex
28            Next firstChartIndex
29        Next targetObject
30 End Sub

```

ChartFlipXYValues.md

```
1 Public Sub ChartFlipXYValues()  
2  
3     Dim targetObject As ChartObject  
4     Dim targetChart As Chart  
5     For Each targetObject In Chart_GetObjectsFromObject(Selection)  
6         Set targetChart = targetObject.Chart  
7  
8         Dim butlSerieses As New Collection  
9         Dim butlSeries As bUTLChartSeries  
10  
11         Dim targetSeries As series  
12         For Each targetSeries In targetChart.SeriesCollection  
13             Set butlSeries = New bUTLChartSeries  
14             butlSeries.UpdateFromChartSeries targetSeries  
15  
16             Dim dummyRange As Range  
17  
18             Set dummyRange = butlSeries.Values  
19             Set butlSeries.Values = butlSeries.XValues  
20             Set butlSeries.XValues = dummyRange  
21  
22             'need to change the series name also  
23             'assume that title is same offset  
24             'code blocked for now  
25             If False And Not butlSeries.name Is Nothing Then  
26                 Dim rowsOffset As Long, columnsOffset As Long  
27                 rowsOffset = butlSeries.name.Row - butlSeries.XValues.Cells  
28                     (1, 1).Row  
29                 columnsOffset = butlSeries.name.Column - butlSeries.XValues.  
30                     Cells(1, 1).Column  
31  
32                 Set butlSeries.name = butlSeries.Values.Cells(1, 1).Offset(  
33                     rowsOffset, columnsOffset)  
34             End If  
35  
36             butlSeries.UpdateSeriesWithNewValues  
37  
38         Next targetSeries  
39     Next targetObject  
40 End Sub
```

```
36
37     ''need to flip axis labels if they exist
38     ''three cases: X only, Y only, X and Y
39
40     If targetChart.Axes(xlCategory).HasTitle And Not targetChart.Axes(
41         xlValue).HasTitle Then
42
43         targetChart.Axes(xlValue).HasTitle = True
44         targetChart.Axes(xlValue).AxisTitle.Text = targetChart.Axes(
45             xlCategory).AxisTitle.Text
46         targetChart.Axes(xlCategory).HasTitle = False
47
48     ElseIf Not targetChart.Axes(xlCategory).HasTitle And targetChart.Axes
49         (xlValue).HasTitle Then
50         targetChart.Axes(xlCategory).HasTitle = True
51         targetChart.Axes(xlCategory).AxisTitle.Text = targetChart.Axes(
52             xlValue).AxisTitle.Text
53         targetChart.Axes(xlValue).HasTitle = False
54
55     ElseIf targetChart.Axes(xlCategory).HasTitle And targetChart.Axes(
56         xlValue).HasTitle Then
57         Dim swapText As String
58
59         swapText = targetChart.Axes(xlCategory).AxisTitle.Text
60
61         targetChart.Axes(xlCategory).AxisTitle.Text = targetChart.Axes(
62             xlValue).AxisTitle.Text
63         targetChart.Axes(xlValue).AxisTitle.Text = swapText
64
65     End If
66
67     Set butlSeriesies = Nothing
68
69 Next targetObject
70
71 End Sub
```

ChartMergeSeries.md

```
1 Public Sub ChartMergeSeries()  
2  
3     Dim targetObject As ChartObject  
4     Dim targetChart As Chart  
5     Dim firstChart As Chart  
6  
7     Dim isFirstChart As Boolean  
8     isFirstChart = True  
9  
10    Application.ScreenUpdating = False  
11  
12    For Each targetObject In Chart_GetObjectsFromObject(Selection)  
13  
14        Set targetChart = targetObject.Chart  
15        If isFirstChart Then  
16            Set firstChart = targetChart  
17            isFirstChart = False  
18        Else  
19            Dim targetSeries As series  
20            For Each targetSeries In targetChart.SeriesCollection  
21  
22                Dim newChartSeries As series  
23                Dim butlSeries As New BUTLChartSeries  
24  
25                butlSeries.UpdateFromChartSeries targetSeries  
26                Set newChartSeries = butlSeries.AddSeriesToChart(firstChart)  
27  
28                newChartSeries.MarkerSize = targetSeries.MarkerSize  
29                newChartSeries.MarkerStyle = targetSeries.MarkerStyle  
30  
31                targetSeries.Delete  
32  
33            Next targetSeries  
34  
35            targetObject.Delete  
36  
37        End If
```

```
38     Next targetObject
39
40     Application.ScreenUpdating = True
41
42 End Sub
```

ChartSplitSeries.md

```
1 Public Sub ChartSplitSeries()
2
3     Dim targetObject As ChartObject
4     Dim targetChart As Chart
5
6     Dim targetSeries As series
7     For Each targetObject In Chart_GetObjectsFromObject(Selection)
8
9         For Each targetSeries In targetObject.Chart.SeriesCollection
10
11             Dim newChartObject As ChartObject
12             Set newChartObject = ActiveSheet.ChartObjects.Add(0, 0, 300, 300)
13
14             Dim newChartSeries As series
15             Dim butlSeries As New bUTLChartSeries
16
17             butlSeries.UpdateFromChartSeries targetSeries
18             Set newChartSeries = butlSeries.AddSeriesToChart(newChartObject.
19                 Chart)
20
21             newChartSeries.MarkerSize = targetSeries.MarkerSize
22             newChartSeries.MarkerStyle = targetSeries.MarkerStyle
23
24             targetSeries.Delete
25
26         Next targetSeries
27
28     targetObject.Delete
29
```

```
30     Next targetObject
31 End Sub
```

DeleteAllCharts.md

```
1 Public Sub DeleteAllCharts()
2
3     If MsgBox("Delete all charts?", vbYesNo) = vbYes Then
4         Application.ScreenUpdating = False
5
6         Dim chartObjectIndex As Long
7         For chartObjectIndex = ActiveSheet.ChartObjects.Count To 1 Step -1
8
9             ActiveSheet.ChartObjects(chartObjectIndex).Delete
10
11         Next chartObjectIndex
12
13         Application.ScreenUpdating = True
14
15     End If
16 End Sub
```

RemoveZeroValueDataLabel.md

```
1 Public Sub RemoveZeroValueDataLabel()
2
3     'uses the ActiveChart, be sure a chart is selected
4     Dim targetChart As Chart
5     Set targetChart = ActiveChart
6
7     Dim targetSeries As series
8     For Each targetSeries In targetChart.SeriesCollection
9
10         Dim seriesValues As Variant
11         seriesValues = targetSeries.Values
12
```

```

13      'include this line if you want to reestablish labels before deleting
14      targetSeries.ApplyDataLabels xlDataLabelsShowLabel, , , , True, False
        , False, False, False
15
16      'loop through values and delete 0-value labels
17      Dim pointIndex As Long
18      For pointIndex = LBound(seriesValues) To UBound(seriesValues)
19          If seriesValues(pointIndex) = 0 Then
20              With targetSeries.Points(pointIndex)
21                  If .HasDataLabel Then .DataLabel.Delete
22              End With
23          End If
24      Next pointIndex
25  Next targetSeries
26 End Sub

```

UpdateFromChartSeries.md

```

1 Public Sub UpdateFromChartSeries(targetSeries As series)
2
3
4     'this will work for the simple case where all items are references
5     Const FIND_STRING As String = "SERIES("
6     Const COMMA As String = ","
7     Const CLOSE_BRACKET As String = ")"
8
9     Set series = targetSeries
10
11     Dim targetForm As Variant
12
13     '=SERIES("Y",Sheet1!$C$8:$C$13,Sheet1!$D$8:$D$13,1)
14
15     'pull in the formula
16     targetForm = targetSeries.Formula
17
18     'uppercase to remove match errors
19     targetForm = UCase(targetForm)
20

```

```

21 'remove the front of the formula
22 targetForm = Replace(targetForm, FIND_STRING, vbNullString)
23
24 'find the first foundPosition
25 Dim foundPosition As Long
26 foundPosition = InStr(targetForm, COMMA)
27
28 If foundPosition > 1 Then
29     'need to catch an error here if a text name is used instead of a
        valid range
30     On Error Resume Next
31     Set Me.name = Range(left(targetForm, foundPosition - 1))
32     If Err <> 0 Then pName = left(targetForm, foundPosition - 1)
33     On Error GoTo 0
34 End If
35
36 'pull out the title from that
37 targetForm = Mid(targetForm, foundPosition + 1)
38
39 foundPosition = InStr(targetForm, COMMA)
40
41 If foundPosition > 1 Then Set Me.XValues = Range(left(targetForm,
        foundPosition - 1))
42
43 targetForm = Mid(targetForm, foundPosition + 1)
44
45 foundPosition = InStr(targetForm, COMMA)
46 Set Me.Values = Range(left(targetForm, foundPosition - 1))
47 targetForm = Mid(targetForm, foundPosition + 1)
48
49 foundPosition = InStr(targetForm, CLOSE_BRACKET)
50 Me.SeriesNumber = left(targetForm, foundPosition - 1)
51
52 Me.ChartType = targetSeries.ChartType
53 End Sub

```

The Worksheet object

introduction to the Worksheet object

This chapter will focus on the aspects of the Worksheet that appear commonly in VBA code. This chapter is a little shorter than others because in general, the Worksheet is a conduit to more useful things. There is very little that takes place within the Worksheet object that is not just a pass through to the more interesting details (e.g. Range or Chart). Having said that, there are a handful of areas that are relevant to the Worksheet and not accessible anywhere else. Those specific areas include:

- Creating and managing Worksheets – this sounds obvious but managing the references to Worksheets becomes a major issue when working with large, complicated workflows
- Print layout, printing, and exporting
- Locking and setting passwords on Worksheets
- Managing the properties of the Worksheet itself including Name, tab color, etc.

TODO: any other Worksheet things?

Of the topics listed above, the most important area is actually creating and managing the Worksheets in a complicated workflow. This is closely related to working with Ranges since presumably you create the Worksheet to put data into or something else into it. Managing the references to Worksheets can be a big deal and determining how best to access or select a given Worksheet can be important. In addition to getting references, there are a handful of times where you actually need to Activate a Worksheet. Knowing when this is and is not required is important.

TODO: when do you have to Activate?

creating and managing Worksheets

This section will focus on how to create a Worksheet and get a reference to new Worksheets. In addition to that, it will discuss managing Worksheets, including rearranging and deleting them.

references to Worksheets

The process for working with Worksheets is the same as all the other Excel Object Model objects: obtain a reference to the object and access its properties. For the Worksheet, there are a handful of ways to obtain a reference to a Worksheet. Those include:

-
- `ActiveSheet`
 - `Worksheets(index)` or `Sheets(index)` global objects
 - `Workbook.Sheets(index)` or `Workbook.Worksheets(index)` with a workbook object
 - VBA references (`Sheet1`, `Sheet2`)
 - Store the reference after creating a new sheet
 - Iterating through `Worksheets` and picking with some criteria
 - Copy a `Worksheet` and then search for the result (see notes below; TODO: add notes)

The basic dividing line of the methods above is when you want to access the `Worksheet` and what you potentially know about it. The simplest approach is when you want some code to run on the `ActiveSheet` because you can just ask for it. Technically, you can avoid most references to the `ActiveSheet` use the unqualified global references, but this can lead to errors later. The business of obtaining a reference to a `Worksheet` using the other means typically only comes up when you are working with multiple `Worksheets`. This is quite common to do.

Once you start working with multiple `Worksheets`, there are a couple of common things you may want to do:

- Apply the same action to multiple sheets
- Process some data on one sheet based on the data on another sheet
- Move data from one sheet to another
- Move a chart or other object from one sheet to another
- Create a throwaway `Worksheet` with some information about the rest of your `Workbook` (e.g. output all the sheet names)

In some of those instances, you are working with multiple sheets because you want to do something (e.g. print layout or formatting) to multiple sheets. In others, you are working on multiple sheets because you know in advance that some task will use data from multiple `Worksheets`. For the former case, you are likely to throw your code into a loop across all `Worksheets` and then use some logic to determine whether or not to apply the action. In the other case, you will likely use a sheet name or index to directly access the sheet you want.

It is worth mentioning that every `Workbook` has built-in dedicated references to the `Worksheets` which can be used. These exist as a part of the Object Model. By default they are called `Sheet1`, `Sheet2`, etc. These objects are always available and provide a direct reference to the worksheet. They can be quite helpful if you rename them from the default names. A couple of important items about these objects:

- They only exist as objects in the current `Workbook`. That is, if you want to access a `Worksheet` in another `Workbook`, this approach will not work. You can technically add a reference to the other

Workbook, but I don't recommend doing that.

- Their naming is independent of the actual sheet name displayed in Excel. This can be incredibly confusing for a new developer (especially if they are not using `Option Explicit`).
- It is very difficult to use these objects to perform some action to multiple Worksheets.

For what it's worth, I've never used the objects directly. I find myself using the sheet name directly when needed. This leads to issues with the name being changed, but at some point searching for the string in code is easier than trying to rename the object in the VBE sidebar. All of the references will break either way.

creating a Worksheet

Aside from referencing an existing Worksheet often times the core task of some automation is to create a new Worksheet. There are a number of reasons you might want to do this:

- A blank sheet is a great starting part for storing some intermediate or final result. It is nearly guaranteed to be the same every time you call for one which is much better than putting new data in an existing sheet.
- You need a blank sheet for the output of some process that is run over a number of items (each analysis gets a new sheet).
- Copying an existing Worksheet and then applying some transformation to the result.
- You created a new Workbook. This adds an extra step but leaves you with the same result as a new sheet alone (unless it was created from a template).

From my own experience, I find that creating a new Worksheet is an absolutely critical task. Very often the goal of using VBA is to automate some task over a range of inputs or possible outputs. This often means that the output for a given command may need to be produced several times. In this case, I regularly create new Worksheets instead of managing the multiple sets of data in one sheet.

In other cases, you may use a temporary intermediate new Worksheet to provide a dumping place for some calculations or other work. This is a much safer approach than to use the existing Worksheet for temporary efforts. Unless you are certain of the contents of an existing Worksheet, there is little reason to avoid creating a new one.

It's worth noting that Excel is quite performant even with a large number of Worksheets. This is especially true if the Worksheets are not linked or related via calculations. My strongest advice on this front is to liberally create new Worksheets and deal with the aftermath later. If you are building a complicated workflow, sometimes the best output is one that is useful but completely disposable. This means that the

output is impressive but due to the speed of the automation there is little reason to save or otherwise consume the resulting file. When this is the case, there is no penalty for disorganized Worksheets if the intended product is still there. Let Excel deal with the references and Ranges etc. while you deal with maintainign the rereferences in VBA.

Having said all of that, creating a Worksheet is incredibly simple `Workbook.Sheets.Add()`. That Function will return the Worksheet object which is a refernece to the new sheet. The new sheet will have a default name. The parameters to `Add` control the location of the new sheet with respect to others. It is very, very unlikely that you will create a new Worksheet and not immediately want the sheet refernece. That is, you will probably always call `Add` with a preceding `Set` to save the reference. This reference can be as good as gold in an automated workflow since an empty Worksheet is a very powerful starting (and possibly daunting) point.

If you need a copy of an existing Worksheet instead of a blank one, the command is quite simple: `Worksheet.Copy()`. This will create a Copy with parameters for lcoation (TODO: is that true?). The major downside of using `Copy` is that it will NOT return a reference to the newly created Worksheet. This is a real travesty because it means you then have to turn around and do some work to find the newly create Worksheet. My preferred approach is to Copy the Worksheet to the first or last location in the Sheet order and then find it there. Once found, you can move the Worksheet to a desired location and then use the reference.

removing a Worksheet

If you need to delete a Worksheet, it is a simple command again: `Worksheet.Delete`. The one downside to this command is that it will fire off a warning prompt if the Worksheet contained any data or was otherwise not “blank”. This warning box will stall the execution of your VBA until it is addressed. This is a major issue for any serious workflow since your users will have to constantly click “Yes” to delete the Worksheet but they may also have no idea what they are deleting. To avoid this issue, you will nearly ALWAYS wrap the `Delete` command with the comannnds to disbale and then reenale the alerts. The typical code looks like:

```
1 Application.DisplayAlerts = False
2 Worksheet.Delete
3 Application.DisplayAlerts = True
```

When doing this dance, be absolutely certain that you reenale the alerts. Excel will not do it for you. You may benefit from creating a new helper Sub which contains the above code as a `DeleteSheet` command

to avoid constantly adding those alerts.

TODO: add a note about when to create a new Worksheet vs. a new Workbook and the pros/cons there (maybe put this in the workflow section of book)

rearranging Worksheets

To rearrange the Worksheets, the command is simple: `Worksheet.Move(Before, After)`. The parametrs there will indicate the sheet ot place it before or after. The real task here is determining whcih sheet to refernece there, but finding that reference is the same task that is described up at the top of the seciton.

AscendSheets.md TODO: move the AscendSheets code elsewhere or delete (not helpful here)

```
1 Public Sub AscendSheets()  
2  
3     Application.ScreenUpdating = False  
4     Dim targetWorkbook As Workbook  
5     Set targetWorkbook = ActiveWorkbook  
6  
7     Dim countOfSheets As Long  
8     countOfSheets = targetWorkbook.Sheets.Count  
9  
10    Dim i As Long  
11    Dim j As Long  
12  
13    With targetWorkbook  
14        For j = 1 To countOfSheets  
15            For i = 1 To countOfSheets - 1  
16                If UCase(.Sheets(i).name) > UCase(.Sheets(i + 1).name) Then .  
                    Sheets(i).Move after:=.Sheets(i + 1)  
17            Next i  
18        Next j  
19    End With  
20  
21    Application.ScreenUpdating = True  
22 End Sub
```

properties and methods on the Worksheet

This section will focus on the specific properties and functions that exist for a Worksheet.

Some of the useful properties of a Worksheet include:

- Name
- Move
- Copy
- Protect/Unprotect
- Range, Cells, Rows, Columns, UsedRange
- The accessors which will give you a Collection of other objects
 - ChartObjects
 - Charts (TODO: that right?)
 - Shapes
 - ListObjects
 - PivotTables
 - Hyperlinks
 - Comments?
- TODO: add others

TODO: determine how to explain these and which to include

LockAllSheets.md

TODO: clean up this code

```
1 Public Sub LockAllSheets()  
2  
3     Dim userPassword As Variant  
4     userPassword = Application.InputBox("Password to lock")  
5  
6     If Not userPassword Then  
7         MsgBox "Cancelled."  
8     Else  
9         Application.ScreenUpdating = False  
10  
11         'Changed to ActiveWorkbook so if add-in is not installed, it will  
            target the active book rather than the xlam
```

```
12     Dim targetSheet As Worksheet
13     For Each targetSheet In ActiveWorkbook.Sheets
14         On Error Resume Next
15         targetSheet.Protect (userPassword)
16     Next
17
18     Application.ScreenUpdating = True
19 End If
20
21 End Sub
```

OutputSheets.md

TODO: clean up this code

```
1 Public Sub OutputSheets()
2
3     Dim outputSheet As Worksheet
4     Set outputSheet = Worksheets.Add(Before:=Worksheets(1))
5     outputSheet.Activate
6
7     Dim outputRange As Range
8     Set outputRange = outputSheet.Range("B2")
9
10    Dim targetRow As Long
11    targetRow = 0
12
13    Dim targetSheet As Worksheet
14    For Each targetSheet In Worksheets
15
16        If targetSheet.name <> outputSheet.name Then
17
18            targetSheet.Hyperlinks.Add _
19                outputRange.Offset(targetRow), "", _
20                "" & targetSheet.name & "!A1", , _
21                targetSheet.name
22            targetRow = targetRow + 1
23
```

```
24         End If
25     Next targetSheet
26
27 End Sub
```

UnlockAllSheets.md

TODO: clean up this code

```
1 Public Sub UnlockAllSheets()
2
3     Dim userPassword As Variant
4     userPassword = Application.InputBox("Password to unlock")
5
6     Dim errorCount As Long
7     errorCount = 0
8
9     If Not userPassword Then
10         MsgBox "Cancelled."
11     Else
12         Application.ScreenUpdating = False
13         'Changed to ActiveWorkbook so if add-in is not installed, it will
           target the active book rather than the xlam
14         Dim targetSheet As Worksheet
15         For Each targetSheet In ActiveWorkbook.Sheets
16             'Let's keep track of the errors to inform the user
17             If Err.Number <> 0 Then errorCount = errorCount + 1
18             Err.Clear
19             On Error Resume Next
20             targetSheet.Unprotect (userPassword)
21
22         Next targetSheet
23         If Err.Number <> 0 Then errorCount = errorCount + 1
24         Application.ScreenUpdating = True
25     End If
26     If errorCount <> 0 Then
27         MsgBox (errorCount & " sheets could not be unlocked due to bad
           password.")
```

```
28 End If
29 End Sub
```

print layout and exporting

This section will focus on the print and export related details of a Worksheet. In particular, it will focus on the details that are typically accessed through the Page Layout menu. This is one of the unique aspects of Worksheets because they are the holder of the print/export information. The main details related to this are:

- Print area
- Page layout – this is a very large object with a lot of properties to be set
- Exporting and printing

The details in this section can be a real time saver because one of the more tedious aspects of working with Excel is ensuring that your reports/graphs/data will print or export correctly. Being able to control these properties with VBA makes it possible to quickly apply the same formatting to a large number of Worksheets without having to click nine million times.

When editing the Page Layout, you can change nearly everything. The one thing to be aware of is related to printers. There are a number of settings in the Worksheet that are internally tied to the default (or active) printer. This shows up if you are attempting to set the page size specifically. If you always use the same printer or have coworkers who use the same printers, you may not notice these issues. It becomes a serious problem when you are trying to make code work for multiple different printers that support or identify page sizes differently.

The best way to see what is available for page settings is to record a macro and change one thing. Excel is a bit aggressive at including all possible settings that could have changed. This is very nice if you want to grab some settings and work them into your code.

There are a couple of other items to describe so you know what they are:

- Using [Zoom](#) and [FitToPages](#) to set the number of pages that the output will be included in (TODO: review)
- TODO: add others

Also, be aware that changing the print settings is a per Worksheet change. This may be obvious since the properties are off the Worksheet, but it is easy to forget this. The nice thing however is that you can just

iterate your Worksheets and apply the same settings to all of them. This is one of the greatest time savers compared to changing properties in Excel (TODO: can these be changed with multi selection?).

Rand_common print settings

TODO: clean up this code

```
1 Sub Rand_CommonPrintSettings()  
2  
3     Application.ScreenUpdating = False  
4     Dim sht As Worksheet  
5  
6     For Each sht In Sheets  
7         sht.PageSetup.PrintArea = ""  
8         sht.ResetAllPageBreaks  
9         sht.PageSetup.PrintArea = ""  
10  
11         With sht.PageSetup  
12             .LeftHeader = ""  
13             .CenterHeader = ""  
14             .RightHeader = ""  
15             .LeftFooter = ""  
16             .CenterFooter = ""  
17             .RightFooter = ""  
18             .LeftMargin = Application.InchesToPoints(0.75)  
19             .RightMargin = Application.InchesToPoints(0.75)  
20             .TopMargin = Application.InchesToPoints(1)  
21             .BottomMargin = Application.InchesToPoints(1)  
22             .HeaderMargin = Application.InchesToPoints(0.5)  
23             .FooterMargin = Application.InchesToPoints(0.5)  
24             .PrintHeadings = False  
25             .PrintGridlines = False  
26             .PrintComments = xlPrintNoComments  
27             .PrintQuality = 600  
28             .CenterHorizontally = False  
29             .CenterVertically = False  
30             .Orientation = xlLandscape  
31             .Draft = False  
32             .PaperSize = xlPaperLetter
```

```
33         .FirstPageNumber = xlAutomatic
34         .Order = xlDownThenOver
35         .BlackAndWhite = False
36         .Zoom = False
37         .FitToPagesWide = 1
38         .FitToPagesTall = False
39         .PrintErrors = xlPrintErrorsDisplayed
40         .OddAndEvenPagesHeaderFooter = False
41         .DifferentFirstPageHeaderFooter = False
42         .ScaleWithDocHeaderFooter = True
43         .AlignMarginsHeaderFooter = False
44         .EvenPage.LeftHeader.Text = ""
45         .EvenPage.CenterHeader.Text = ""
46         .EvenPage.RightHeader.Text = ""
47         .EvenPage.LeftFooter.Text = ""
48         .EvenPage.CenterFooter.Text = ""
49         .EvenPage.RightFooter.Text = ""
50         .FirstPage.LeftHeader.Text = ""
51         .FirstPage.CenterHeader.Text = ""
52         .FirstPage.RightHeader.Text = ""
53         .FirstPage.LeftFooter.Text = ""
54         .FirstPage.CenterFooter.Text = ""
55         .FirstPage.RightFooter.Text = ""
56         .PrintTitleRows = ""
57         .PrintTitleColumns = ""
58     End With
59 Next sht
60
61     Application.ScreenUpdating = True
62 End Sub
```

The Workbook object

introduction to the Workbook

This chapter will focus on the Workbook object. There are only a handful of things that are done at the Workbook level, but those few items are quite important. The main things to be done with a Workbook are:

-
- Create, open, close, and save Workbooks
 - Manage references to Workbooks
 - Change certain properties of the Workbook (TODO: are there any?)
 - Access certain properties of the Workbook (e.g. Path)

This will be a quick chapter since the items below are fairly straight forward. Having said that, this chapter will be quite relevant if you are working through a complex workflow that involves creating temporary or new Workbooks to store data or analysis. Being able to create and work with Workbooks will give you the confidence to fire up a new Workbook for a one-off analysis instead of polluting the existing Workbook with a one-off Worksheet or other data dump.

understanding the Workbook Object Model

The Workbook is an object that serves two main purposes:

- Provide a foothold to a number of other more useful functions (e.g. Sheets)
- Provide a reference to the underlying data within a spreadsheet while working through a workflow

For the first point, the goal of the Workbook is to actually use its properties to do some task. For the latter point, the Workbook is simply a container that holds data which is necessary to interact with while creating a workflow. To be honest, there is very little of use within the Workbook object that is not a reference to some other object. Typically, the main tasks to actually be done with the Workbook are to Open, Save, and Close them. That is, you move away from the Workbook object as quickly as you can because you just need a reference.

working with Workbook references

There are a couple of ways to obtain a reference to a Workbook that are useful:

- `ActiveWorkbook` - refers to the Workbook that has focus
- `ThisWorkbook` - refers to the Workbook which contains the code that is executing
- `Workbooks.Open()` - will open a Workbook and return a reference
- `Workbooks(index)` - will grab a reference to the currently opened Workbook
- `Workbooks.Add()` - will create a new blank Workbook or a Workbook according to a supplied template

I find that all of those approaches are used equally across my code. The one exception might be `ThisWorkbook` which I typically avoid. In reality, I should probably use it more because I find myself going to some length to maintain a reference to a Workbook while opening or creating Workbooks.

For Workbooks, the biggest thing to be aware of is that there are a number of unqualified references that exist within VBA that are a part of the ActiveWorkbook. Those include:

- Worksheets and Sheets
- Names?

These unqualified references can really bite you when you are expecting it. The problem with unqualified references is that they work great initially, before the workflow becomes complex. They will then silently fail later when you start creating new Workbooks and otherwise changing the focus or active Workbook. The problem is that nearly all of the unqualified references apply to the ActiveWorkbook. Working with Workbooks is the one task that will often change the focus of Excel regardless of how you create things.

useful properties of the Workbook

Although I have railed against the Workbook object, there are a handful of things that it can do:

- Reference [Names](#) which contains all of the global named ranges
- Others?
- Charts?

Worksheets vs. Sheets

When working with Worksheets, there are a pair of objects which will provide access to the underlying Sheets. They are different in how they handle Charts which are visible as a Worksheet. The rule is: Sheets will return the Charts, whereas Worksheets will only return the list of objects which are actually Worksheets. If you do not use Charts as Worksheets, then you will never notice a difference between these two objects. The one thing you will notice is that the ActiveWorksheet will not be of type Worksheet which means that you can never get Intellisense on one of the most useful objects.

The Application object

introduction to the Application

This chapter will focus on the Application object. There are a number of significant details of Excel and its interaction with VBA that are controlled from the Application. In particular, the Application is responsible for providing access to calculation related properties and user display preferences.

The major features of the Application object include:

- Controlling the calculation
- Controlling events and other visual effects
- Controlling the StatusBar and providing feedback during a macro
- Ability to execute arbitrary formulas within VBA

TODO: any other items for this list?

The Application can do a number of other things related to Excel settings which will not be covered here.

Controlling calculations

TODO: add content

Controlling events and visuals

TODO: add content

Controlling the StatusBar

TODO: add content

Executing arbitrary functions

TODO: add content

overview of 4 adv processing

Advanced processing should include some recipe type sections that go through the more advanced aspects of working up VBA code.

This could focus on:

- Speed improvements and how to do it (disable screen, events, calculation) and how to undo it
- Working with arrays of values instead of outputting a cell at a time

-
- Cranking through an entire automated workflow without user interaction: creating new workbooks, worksheets, charts, formulas and then outputting it all to PDF
 - Focus on the interplay of manual steps and code (sometimes you have to run part of the code to see what to do next; other times you can sit down and type the whole thing out)
 - Cleaning up macro recorder code (some discussion about what works well/doesn't)
 - How to avoid `Select` and why
 - Using `DoEvents` to wait a set amount of time
 - Using `Application.OnWait` (?) to do some thing at a regular time
 - Parsing through existing formulas or values and manipulating with confidence
 - Reading and writing to external files
 - Working with the file system to do some processing
 - Running through a folder or batch of files and doing something with each one
 - Structuring code in a way that the different pieces can be called on their own
 - Going through a workflow that involves using other office products
 - Strategy for identifying cells using Styles and working through them; effectively a tag feature

The long list of sections here says that maybe there is enough code to put together a couple of “case study” type things that break down the development of an entire workflow. This could related to charting/processing or some other thing.

TODO: consider going through StackOverflow answers to see what the most common slightly advanced topics are that come up

some thoughts on creating a workflow

If you are sitting down to create an advanced workflow, there are a handful of things to consider. The list that follows is not complete nor is it meant to include items that are always relevant. The problem with these lists is that with a general programming environmetn like Excel, it's impossible to describe everything to consider. HAVING said that, I have built tons of these workflows and can comment on a handful of things that nearly always come up. The first item to touch on is the general structure/outline of a VBA workflow. This breakdown seems to always hold true.

Your VBA workflow will contain steps or sub steps that roughly be described as:

- Inputs
- Intermediate results
- Outputs

If your workflow is advanced enough to include a number of sub steps built from other steps, then you are likely to find that this breakdown applies within and across levels of your workflow. That is, the outputs of one step may very well be the inputs to another step. The intermediate result from one action will be the input for another.

When thinking in terms of these categories, there is a useful distinction to make that is somewhat unique to Excel programming: do your inputs and outputs exist in the Excel spreadsheet or only in the VBA code? This distinction is meaningful because it helps you think about how much of your workflow is the automation of otherwise human tasks (which could still be done by a human) vs. steps that are purely programmatic and could not be replicated by a human. Where this distinction is most likely to show up is when you are deciding where and how to perform a calculation. In theory, all of the Excel spreadsheet could be done in VBA via the `WorksheetFunction` object. Doing everything in VBA defeats a large part of the benefit that comes from programming with VBA. It's easy to lose sight of this when you see a clean code-only solution to a problem, but realize that the greatest benefit to programming alongside Excel is that you have a powerful, human readable scratch pad that lives alongside your VBA.

As a comment, I have seen incredibly complicated workflows that involved detailed calculations of arrays that were done exclusively in VBA. The math was fine and the results were generally useful. The problem was that there was no way to spot check a given result without debugging code. This makes it nearly impossible for someone without VBA experience to validate your work. It also provides you job security, but ideally you'd gain security by other means.

A better marriage of VBA and Excel is to utilize Excel for all of the tasks it's great at: calculation, visual outputs, charting, page layouts and printing, and also the deep data oriented features (sorting, filtering, etc). Where VBA comes in handy, is wiring together all of these items into a coherent package that runs more efficiently than anything that a human alone could do. The best workflows typically take a very simply underlying spreadsheet and apply to a large number of items. In this way, you are able to spot check a single result, verify the formulas, and investigate an interesting result. You are also free to just hit go and have 10,000+ results streamed into a table for consumption. If you find yourself looking for all sorts of tricks to avoid using the underlying Excel model for your programming, I'd strongly encourage to just switch to a fully programmatic language that does not have the Excel UI. You will save yourself a ton of headache. If you are only aware of VBA and looking to push the envelope in terms of performance, then that's an OK place to be. Just realize that there are better alternatives to Excel for high performance computing.

inputs

Back to the overall structure, there are inputs, outputs, and intermediate results. Depending on what you are doing, some of these aspects may just exist on/within the spreadsheet and be easy to overlook as an input or output. It's not until you wire up a more complicated workflow that you are forced to recognize the different pieces in a spreadsheet for what they are. On the input front, there are a handful of items that should trigger your thought of "input":

- A file that contains some data to be processed, filtered, etc.
- A couple of columns in a spreadsheet that need to be processed and then charted.
- 15 scattered cells that meet some criteria within a block of data
- The contents of the clipboard from another program
- The formatting of a couple of cells

All of those items could be used as the input to a VBA workflow. Some of these items are odd to think about if you are coming from another programming environment. What does it mean for the formatting of a cell to be an input? Well Excel provides you with a rich Object Model full of metadata about all of the various cells of data. That metadata can be as useful as actually structured data if there is a structure to it. I've seen it countless times where someone has methodically bolded all of the cells of interest in a block of data. That bold format is as good as some field called `Important = True` which could then be processed in another language. Instead of that flag, you just check `Range.Format.Bold = True`. This of course relies on an implicit assumption about how the data is structured, but this is common in the Excel/VBA world.

Excel also has a very strong UI which makes it possible to immediately solicit user input in a way that is not easily replicated coming from other languages. Where this shows up most frequently is when you start using the `ActiveCell`, `ActiveWorkbook`, `Selection` and other objects which are dependent on user input. In a lot of other languages you have to spend a ton of time pointing the program to the correct file, or rows, or columns, or other items to process. In Excel, you leverage the fact that most people know how to select or activate items they want, and you can use that user input as an actual input to your VBA. This becomes quite powerful when you are building utility code that may be used across multiple workbooks. This becomes much harder in other languages where the idea of a "open file" is far less well defined. You certainly cannot query the selected cells in an R data table.

outputs

The next item to hit are the outputs of a workflow. Very often, the outputs are obvious because you had some task to complete with VBA, and the outputs are simply the results of that task. Where things become more complicated is when you string together steps and the output of one becomes the input for the next. When that happens, you often have to decide what intermediate format is best for the transfer. You may or may not settle on a format that is easily human consumable. There are tradeoffs here that will be discussed later. The output of a workflow can be a number of things:

- A string, number, cell, row, column, or table of data that was processed by the VBA
- A chart
- A collection of shapes
- A worksheet that includes any of the items above
- A workbook that includes a number of constructed worksheets
- A change to the formatting of a number of cells
- A change to the properties of a Range, Worksheet or Workbook
- A new text file written to disk
- Some result output to the Clipboard
- Pages of physical paper if your VBA prints
- Some change to the filesystem or disk
- Some other program opened or run with specific parameters

This is a shortened list since the possibilities here are closer to endless. The idea however is that you can effect a large amount of change from VBA and so your possible outputs can be quite numerous. A typical workflow will accumulate a large number of these outputs individually and will then produce some final product which highlights some of those outputs.

intermediate results

When discussing intermediate results, it is generally best to limit your thoughts to whatever will live only in VBA. In that sense, the question of intermediate results is: what programming constructs can exist without the user ever seeing them? Sometimes you need to determine the unique items in a list to do some processing. Do you generate that list of unique items in Excel somewhere? Or, do you determine the unique items using VBA and then output some result which may or may not include the full list of unique items. If you are doing the former, Excel provides a nice `RemoveDuplicates` function which will replicate the `Data->Remove Duplicates` functionality. This works great if you want the user to see the

final list of values. You can also use a [Dictionary](#) in VBA to only store the unique values from a list. In this sense, the [Dictionary](#) represents an intermediate value that may not be shown to the user. You will make this decision several times before you realize that you are deciding whether or not something should exist in VBA only. Often times, the decision does not matter, but for certain workflows it can make a huge difference.

An example is a multi step process where you might want the user to verify the calculations so far and correct any errors. This can technically be done with VBA or Excel, but it is much easier to ask a user to verify an Excel spreadsheet than to debug the code and check [Locals](#). If you need to do this verification step, then it makes a lot of sense to use an intermediate result that dumps back into Excel. In this sense, you've taken an intermediate result and converted it to an output. That output may or may not be modified by the user and it then becomes the input for the next step.

putting it all together

Having given a snapshot of the options for inputs and outputs, it's worth commenting generally on how they all fit together. Your goal should be to build a workflow that consists of steps that can all be described individually and possibly run on their own. Your task is then generating these individual steps and determining how to wire them together. The most common approach to building these workflows is that you start with some single task and then the scope expands as the analysis expands. You can build the ultimate workhorse of a workflow initially, or you can adapt your code to the task as the task comes into view. Depending on where you're starting and the definition at the start, you will determine how complicated to make things at the start.

It is very common to start with a single, straight-through workflow and then build it out into Modules as the work expands. In this way, you are constantly reevaluating the inputs and output of your program to build the smaller blocks which need these definitions. In my experience, nearly all VBA workflows will take shape in this process eventually. It's quite rare to build a complicated workflow once and for all. Generally you start simple and end up with a full featured application at the end.

overview of 4.5 events

chapter will focus on using events to interact with the user and also to drive more functional spreadsheets the major events to focus on are the [Workbook](#) events, including:

-
- `SelectionChanged` which can be used to track when the user clicks on something (do this if clicking in this row)
 - `Changed` which allows for watching cells and doing specific things if the change was somewhere specific
 - using the Intersect technique to determine if the change was in an area of interest
 - disabling events while making changes during events
 - `Application.OnTime` event to trigger something to take place at a given interval

Other ways to interact with events include via class modules with the `WithEvents` designation. These can be used to associate an object with an event and then wire up the code separate from the original macro code. This section might be useful for charting events if I ever get that code put together

Other areas where events take place is via the Ribbon and also via different controls that can live on the sheet. It would be good to discuss these as well.

common events

When talking about events, there are a couple of high level details to touch on:

- Where the events occur? That is, which object owns the event and how do you hook into it?
- When does the event occur?
- What are you allowed or not allowed to do while responding to the event?

For spreadsheets, the events tend to occur within the objects of interest: Worksheet, Workbook, others (TODO: is that right?).

The most common events are associated with the Workbook and Worksheet. If you want to tie into those events, you can typically just add a new handler using the VBE. This process is actually fairly straightforward. The task becomes more difficult when you want to tie into an event but you are not certain which object will fire the event, or you want to track an event that takes place outside of your code.

The main consideration when working with event handling code is that you need to be sensitive to the fact that you can enter an endless loop if you accidentally trigger the same event as the one you are responding to. This is surprisingly easy to do if you are tied into the `Changed` or `Selection_Changed` events which trigger quite frequently.

callbacks

One important point here is that all events are handled via callbacks. That is, you will create a Sub with a specific name and a specific signature which VBA then uses when the event occurs. This callback is important because it includes the information that you will need to discern what happened with the event. Each type of event can include its own specific parameters and your code can respond to them accordingly. This is important because if a cell was Changed, you will want different information than when a Worksheet was activated. In general, VBA is good about providing you useful parameters so that your events can properly determine what took place. Despite the good parameters, you will very likely need to include If/Then code to determine if your event needs further processing.

specific events

For actual event handling code, it makes most sense to take a look at the specific events that can occur and show some techniques for handling them.

Worksheet

The Worksheet has a number of events which are commonly used. These include:

- Changed
- SelectionChanged
- Activate

These events roughly correspond to their name and are easy enough to handle. The idea with these is that you have a specific worksheet that you want to monitor for a specific event. In that case, you add the event using the VBE and then add the handling code.

The most common approaches for using these events is to track what the user is doing and then provide some additional functionality based on their actions. There are a number of reasons that you might want to respond to their input:

- Advanced usability where you allow the act of selecting a cell or cells to determine that some macro should run. You could imagine on a certain sheet that selecting a new cell may mean “please load more data about this row” and the VBA responds accordingly.
- Validation of user input. It is common to watch what the user is changing and then determine if that change is allowed or not based on specific rules.

-
- Starting a new action with some user input. I have previously used editing a cell to trigger a goal seek on that cell. This was quite nice because the VBA would undo my edit and then goal seek the previous cell to a new value based on its formula. This provided a very slick means of trigger goal seek without having to collect further user input.
 - Refreshing some display. It's possible you set calculations to manual and then force a recalculation each time the Worksheet comes into focus.

For the Worksheet, the typical flow is that you will create events at the Worksheet level only if you know that you will only want the code for a single Worksheet (or you are willing to duplicate it across Worksheets). If you want to have the same code run for *all* worksheets, you should look at the Workbook events which provide better views of the entire Workbook.

For some examples here, I will show you how to do the goal seek business along with a separate event which watches user Selection and then processes the cells accordingly.

TODO: add the code and description for the Goal Seek event

TODO: add the code and desc for some event which activates on Selection

Workbooks

For Workbooks, you have a lot of the same events as for a Worksheet. These events take the same parameters (TODO: is that right?) but allow you to watch for that event across all Worksheets in a Workbook. Depending on what you are watching for, this either makes perfect sense or is a real burden with false events that are not interesting. You will have to determine the proper scope for your events depending on what you need them to do. There are not fast rules here. The summary of possible events then includes:

- Changed
- SelectionChange
- Activated
- Opened
- BeforeSave
- Other Save events
- Closing

TODO: add some callback parameters above (and verify names)

TODO: review other events to see what may be useful

These events are similar to Worksheets except that they give you additional hooks that only make sense for a Workbook, specifically related to Saving, Opening, and Closing. These events can be quite useful if you want to do some amount of processing before the file is saved. One common approach I have taken is to delete extraneous data from a workflow spreadsheet to reduce the size and save time for a file. This can be used to great effect if your processing spreadsheet is generally pretty lean without the data it processes. You could also use this to delete a Chart that is large and having a big impact on file size. Once the file is opened, you can then use VBA to recreate the chart.

In some cases, these events are used for that type of example where it seems like a lot of work to save some amount of hassle. Oftentimes, this is the case. You can spend a lot of time with event code to make it do exactly what you want. Sometimes for a user-focused spreadsheet, however, this is the level of detail that is required to ensure that everything will work every time for everyone.

TODO: add an example and desc for a data removal VBA

Application

There are also a couple of events that exist at the Application level. These include:

- OnWait
- TODO: any others?

Application.OnWait can be used to trigger an event at some point in the future. This can then be used to trigger a block of code which runs at an interval by having the triggered code start a new event in the future. In this way, you can use VBA to start a timer which executes every so often.

TODO: add the OnWait code for a timer

TODO: find another examples

common patterns

There are a number of patterns that are very common with Events. These patterns typically exist to avoid causing a problem or to avoid extra work where possible. Most VBA is not performance critical, but it is possible for an event to be called hundreds of times for a given chunk of code. Since this is true, you can start to have an immediate impact on performance if your event handling code includes a number of unnecessary steps. As a side note, this is a good reminder that when trying to speed up code, you will nearly always do better to add `Application.EnableEvents = False` before your performance critical code; this assumes that your VBA does not rely on events firing to function properly.

Intersect

The first is the `Intersect` technique to determine if a Range that was affected by an event was a Range of interest. With this approach, you define a Range which includes your “interesting” cells. You then do a `If Not Intersect(rngEvent, rngTarget) Is Nothing` to see if the intersection of the callback Range and the desired Range overlap. If they overlap, when you typically execute some code. This allows you to quickly filter out Ranges which have changed but are not relevant or whatever code you need to run.

TODO: add a code sample here

`Application.EnableEvents = False`

One of the biggest gotchas with Events is that you can quickly and accidentally create an endless loop of Event code running if your event handler is able to retrigger the original event. This is quite common if you are looking at the Selection and then change the selected cell. The same can happen if you are using an event to watch for a change and then you respond with additional changes. Both of these accidents are so common, that you should seriously consider always disabling events in your handler. It is quite rare that you will need an other event to fire following your own processing.

The main thing to remember here is that you really need to enable events again. Excel will not do this for you. You can create odd situations if you have an error in your code that goes unchecked. This situation can mean that events are disabled. For really sensitive, user focused code, you should add a proper error handler and enable events following that.

To handle this event, the code is quite simple:

```
1 Sub EventHandler()  
2     'disable events  
3     Application.EnableEvents = False  
4  
5     ' do some stuff  
6  
7     'reenable events  
8     Application.EnableEvents = True  
9 End Sub
```

more advanced events

This section will focus on using events in more advanced settings. In particular, the focus here will be on using Class Modules to allow for events to be attached to arbitrary objects that are not necessarily known at compile time. This is an advanced approach that is typically not required. Where it may be helpful is if you are building library code that needs to work in a range of settings. It may also be needed if you are trying to attach events to a Worksheet that will not exist until some other VBA has been run. In this case, you will attach to the same events as above, but you will add the event after the Worksheet has been created. It's worth noting for that specific example that the Workbook can handle a large number of events on the Worksheet and will work for Worksheets that were created later.

TODO: add a section explaining how to use WithEvents

TODO: add some examples of attaching events to a new Worksheet.

SetUpKeyboardHooksForSelection.md

```
1 Public Sub SetUpKeyboardHooksForSelection()  
2  
3  
4     'SHIFT =      +  
5     'CTRL  =      ^  
6     'ALT   =      %  
7  
8     'set up the keys for the selection mover  
9     Application.OnKey "^%{RIGHT}", "SelectionOffsetRight"  
10    Application.OnKey "^%{LEFT}", "SelectionOffsetLeft"  
11    Application.OnKey "^%{UP}", "SelectionOffsetUp"  
12    Application.OnKey "^%{DOWN}", "SelectionOffsetDown"  
13  
14    'set up the keys for the indent level  
15    Application.OnKey "+^%{RIGHT}", "Formatting_IncreaseIndentLevel"  
16    Application.OnKey "+^%{LEFT}", "Formatting_DecreaseIndentLevel"  
17  
18 End Sub
```

overview of 7 user forms and input

Some sections to include here:

- using the Application.InputBox to get different types of input (especially Ranges)
- creating a UserForm and wiring up events
- interacting with the spreadsheet from a UserForm
- a quick summary of the different pieces, when they're useful and specific/common properties

at the end of the day, there is not much too special about forms other than knowing what the different pieces are this should be a relatively quick chapter since most of the reference material is elsewhere

introduction to UserForms

This chapter will focus on how to use UserForms to create interface that allow the user to interact with your VBA code. UserForms can be used from anything to simple text inputs to very complicated forms. There is really no limit to what you can do with UserForms, but at some point you will hit the limit of what you want to do inside the VBE. Some folks will push the limit and develop fully featured programs in Excel. I'd highly recommend you not do that and instead use UserForms to augment a good usage of VBA with useful interactivity.

When considering whether or not to use UserForms, there are a handful of pros and cons to using them.

Pros to using UserForms

- Provide a form to display/edit user input independent of Excel
- Provide for much better interaction with the user via "normal" programming events click, keyboard input, etc.
- Allow your program to collect several pieces of information before completing an action, especially if some real time process of the information is useful
- Provide a form that can "sit" on top of Excel and provide helper functionality or application specific functionality

Cons to using UserForms

There are a number of alternatives to creating a UserForm that are worth considering before committing to UserForms for a specific application. Those alternatives and the cons against UserForms include:

- Editing the code of a UserForm can be a bit of a nuisance because you have to flip between design and code views

-
- The InputBox provides a simple way to collect a number of different input types without needing to create your own form. For simple inputs (including Ranges), the InputBox is typically simpler and more consistent across applications
 - Some types of inputs (including lists) can be easier to manage in a non-VBA context by using default Excel features. For example, you do not need a ListBox on a UserForm if you can put a Table somewhere in the spreadsheet.
 - If you are trying to use some form of version control on your source code, UserForms are very difficult to manage and version.
 - If you want to provide buttons to perform an action, the Ribbon can be much more robust. Of course editing the Ribbon can be a different pain, and I've gone the other way on this point before.

Once you've decided you want to use a UserForm to provide for user input/interaction, there are a number of areas that are important. Those areas from start to finish are:

- Adding a UserForm to an existing Workbook or addin
- Using a Sub to make a UserForm show up using a keyboard shortcut or button or some other means
- Adding controls to UserForm and using those inputs to drive VBA
- Working with a UserForm to process input and update the UserForm
- Using the non-control events to provide interactivity

creating a UserForm

Creating a UserForm is a simple process: open the VBE and then right click to Insert -> UserForm. This will give you a default UserForm that is blank, has a default name, and is a default size. If you're lucky, this will also open the UserForm for editing and show you the toolbox which provides controls to edit. Once the form is created, there are a couple of things which you should do immediately, before you forget:

- Change the name of the form to something more useful than UserForm1
- Change the **Caption** on the form to something better than UserForm
- Consider changing the **ShowModal** property if you know you do not want a modal dialog

Once those items are done (or decided against) you can start adding controls to the UserForm and changing its size.

TODO: add pictures of the steps

making that UserForm show up

Once your UserForm is created, there are a couple of ways of showing it on screen:

- Run any code from the VBE that is contained within the form. This will show the form.
- Create an instance of the form somewhere and show it

For those two methods, the latter is really the only one that will work for user applications or other “real” uses. If you are simply testing or doing things for yourself, then hitting F5 in the VBE may not be a large ask.

For the former, see the code below for an example of how to show the form.

```
1 Dim frm as UserForm
2 Set frm = New UserForm
3
4 frm.Show
```

adding controls to a UserForm and wiring them up

Once your UserForm is created and the defaults are changed, your next task is to do something useful with the form. To that end, you will quickly need to add controls to the form and then wire those forms to useful actions. Adding the controls to the form is a straight forward process: show the Toolbox and then drag the items onto the form. Once you have dragged out a button, text box, and possibly a ListBox, you can simply copy and paste the previous items and avoid the Toolbox all around. There are a handful of controls that are not in the Toolbox by default. My strong advice here is to not use those controls if you are deploying this addin. Inevitably, some user will not have the OCX file or whatever is required to make it work. Just pass. Having said that, you may need to add a Date picker or possibly a RefEdit which are not included here (TODO: is that true about RefEdit?).

Dragging a control onto the form is fairly easy compared to the actual task of making a control do something useful. Below is a quick primer on how the different controls work, which properties are important, and will give you a guide for accomplishing 90% of what can be done with forms.

CommandButton

The CommandButton or simply button is one of the most common controls to use. Its use is simple, known to everyone, and easy enough to program against. A button does one thing: get clicked. The event you

want to know about is the `_Clicked` event. Fortunately, the VBE will automatically create and wire up this event if you double click the button on the Designer version of the form. This makes it dead simple to create the button code that you want: just double click the button.

Note that the default event will be created with the current name of the control. To avoid this, you need to change the name of the button before you create the event. Be aware that VBA and the VBE are not that smart with respect to naming things and wiring up changes. If you change the name of the button after you create the event, your event will not work. You should not change the button name after creating the event (or plan to recreate it).

Other properties of the button that might be used:

- Value - will change the text that is displayed (TODO: is this right?)
- Enabled - will change whether the button can be pressed and will change the visuals. Useful when you want to show that an option could be possible but is not currently allowed or enabled
- Formatting and other visuals - you may change this on the property editor but it is far less common to modify the formatting once you are running. It can be done but is not common.

That's it; buttons are simple.

CheckBox and Radio

The CheckBox and Radio are cousins (or siblings?) of each other and will be dealt with at once. They allow for a Boolean selection of an option. For the CheckBox, you are allowed to indicate the on/off state of a given button. For a Radio, you are allowed to indicate the on/off state for a single option *within a group of options*. The main thing to note about the Radio is that by selecting one item, you will unselect the others. In this way, the uses of these two controls maps naturally to the tasks you are likely to see.

Aside from the Name, the main items to deal with are:

- Clicked event - just double click or get this one
- Value - note you get this by default using the name, but it will include a Boolean of the selected state
- Enabled - can be used to disable the control

That's about it. You can change the formatting and other stuff, but these items typically exist to get an input and get to the real work. They are very common when you are providing options to the user or otherwise want to direct downstream If/Switch statements.

Beware that the Click event may be changed multiple times depending on how it was triggered (TODO: is that right?).

TextBox

The TextBox is another simple one: it provides a means for the user to provide some text input. They work great for a range of things including input and output, although input is more typical. The idea is simple, the user provides a string and you use it somewhere. The properties to know:

- Value - this gets or sets the value that is displayed
- Enabled - can be used to disable the control (TODO: same as readonly?)

In terms of events, the main one to watch for is the KeyPress (TODO: or changed?). The idea is simple, if you want to track the input of the user, you tag along for that event and can respond to their key presses. The common uses of this are:

- Close a form or clear an input when ESC is pressed
- Do some action when ENTER is pressed
- Provide some form of validation or checking as the user types to either modify their input (e.g. ignore dashes) or otherwise update the UI based on their input.

TODO: add some additional content here about the event and its callback/parameters

That's it.

ListBox

The ListBox is one control that has a number of options and a means of using it that are less obvious than the other controls. It's a shame really that the ListBox is so unintuitive in VBA because it is quite powerful and other programming languages have handled this better. The idea behind a ListBox is that it provides a list of items whose use can vary according to what you want. Some common applications include:

- Allow the user to select from one or multiple options in a list
- Provide some output to the user (and possibly then use that output as the input for next step)

The input/output decision here is somewhat critical because the things that will annoy you about the ListBox break on this point. If you are collecting input, then really you have to also deal with output because at the end of the day, you have to put something in the ListBox in order for a user to select it. Once you've handled the output stuff, then determining which items have been selected by the user is straightforward enough. Therefore, covering the output part is a good starting point.

To put items into the ListBox, you need to modify the List collection on the object. There are two ways to do this:

-
- Directly, via the List object
 - Indirectly, using the `AddItem` command

Either way you go, you have a couple of decisions after adding the item: what text do you want displayed for the item and do you want multiple columns? If you are dealing with a single column, then you can simply add the text in the call for an addition and that's all. If you are working with columns, then you will need to do two things:

- Set up the columns (using the editor or via commands) (TODO: add pictures or code here)
- Call the command to set the fields using the row and column number (TODO: add some code)

Although I have described a simple process here, oftentimes, you will deal with something that is more complicated. The issue comes when you want to maintain some reference to an object but you are required to use a string for display purposes. This means that you need some means of maintaining that reference back to the object. There are options for dealing with this:

- Rely on the index of the objects matching (and not changing) and simply use the row index
- Create a Dictionary that stores the link between the string and the object
- Use some other object or Collection that can reference the object back to the string
- Serialize the object into the ListBox value (if multiple fields, join with a `|` or similar)

Each of those approaches has its pros and cons, but the main idea is that you are often forced to deal with something that is typically much easier in other languages. My general approach is to rely on row index if I know that changes are not possible. This is common for a lot of code since you are likely to control both sides. If that is not ideal, then you can typically find some way to store a reference between the display value and the object using a Dictionary.

Once you have the information in the ListBox, you can simply iterate the `Items` by index and check the `Selected(index)` property to see if the item is selected. Note that if you do not allow multiple selection, then you can also use the `SelectedIndex` property (TODO: is that right?).

TODO: add some code here to demonstrate iterate through a ListBox

Although this section has the most text, the ListBox is not always a pain to deal with. Typically they are much better than the alternatives (like using the Excel spreadsheet somehow) but require that you remember some boilerplate for accessing and changing items.

Other Controls

There are a couple of other controls that you may see that are summarized here:

-
- Label: these don't do much other than provide some fixed text when could be changed later (I rarely ever do it)
 - RefEdit: this control technically allows you to select a Range from Excel. They are quite buggy. Depending on your main goal, you may do much better to use `Application.InputBox(Type:=8)` to access a Range.
 - Tabs: these can be helpful for organizing a complicated workflow. You will find yourself wanting to change the active tab and possibly limit access to later tabs.
 - Wells?, whatever it's called, they allow you to Group controls. These may be required for a Radio to work like you want (if you have multiple sets of Radios on a single form).
 -

doing actions on a UserForm

This section will focus on performing commands on a UserForm without leaving the UserForm. This looks mostly like normal forms programming.

Programming on a UserForm is one area of VBA that is largely independent of Excel. Yes, you are able to access the Object Model from a form, but most of the programming on a form is simple related to the form. This is also the one area of VBA where if you have done it before in another language, your experience will transfer nearly 1:1. Forms programming is largely all about building a good UI that meets your needs. You can do a lot with VBA in terms of events and other sorts of dynamic programming, but most of the time you just make the form and get on with the real work.

Some of the common things you will want to do when programming on a form include:

- Creating event handlers
- Parsing and responding to user input
- Populating data in the UserForm from the Object Model
- Accessing Properties of controls to change or use

Event Handlers

Event Handlers are at the core of User Forms and making them useful. To be clear, your Form will do nothing without events. You could use it to display static content from the designer mode, but it will do nothing useful. To make your Form become useful, you add Controls to it and then add Events to those Controls. Event

Handlers are the glue (or wires) that take the actions performed on Controls and direct them somewhere useful. Events control everything from Clicking, Loading, Typing and everything else. Each Control has a unique set of events depending on what it can do, but in general, there's a bit of overlap between different controls.

To add an event handler, there are a couple of options:

- Double click on the Control in Design Mode, and you will get the default event handler created
- Go to the code view, and select the Control and then Event you want from the drop downs (TODO: add image)
- Type the Event handler based on the name of the Control and the event you want

If you know the default events, then option 1 is as good as the others. If you want to see a list of events before creating one, then you will go with option 2. You will pretty much never type the event handler out by hand unless you are copying it from somewhere else.

Once you have created the handler, you simply add the code that you want to fire in the event. One good tip here is to use the event handler to call other Subs. It's a good habit to not put logic or other execution based code into Event Handlers. The reason for this is that you may want to perform the same action from multiple events. Putting the code in a handler makes it difficult to reuse the code because some handlers have parameters and other details that make it hard to arbitrarily call them. Of course, I regularly put code into event handlers, but at least I know I should avoid it. I am constantly reminded of why to avoid it when I have to extract code from one event to put into a Sub to call from another event.

One important note about Event handlers is that the handler can have some number of parameters that are included in the handler signature. These parameters are typically used to pass along information related to the event. For example the key press event contains the key code of the key that was pressed. The Click event however has no parameters. The presence of parameters is easy to check when the VBE creates the handler for an event since it will give the parameters.

TODO: given an example of using Handlers?

TODO: include a blurb about the Initialize event (if it was not addressed earlier)

Processing User Input

User Input on a User Form is one of the most critical aspects of making them. It is less common to use a Form purely for output of information (although that is done). Typically, you use a Form to provide input in a format that is easier to use than the default Excel interface. There are a handful of Controls which are

viewed as collectors of user input. You can then process the input in an EventHandler or in other code which accesses the properties of the Control. Those common controls are:

- **TextBox:** Works great when you want to control a single value from the user. You can then parse the string into a number or whatever else you need
- **ListBox:** Works great for allowing the user to select from a list but still being able to see multiple items in the list. Also supports multiple selection
- **ComboBox:** Same as ListBox but the control collapses to a single line when you are not selecting items. Does not allow for multiple selection.
- **CheckBox or RadioButton:** Allow the user to make a selection between choices while seeing the choices
- **Button:** Really allows a user to input a single click
- **RefEdit:** Not recommended but it allows you to select a Range from the Spreadsheet.
- **TODO:** any others (number spinner?)

For each of those Controls, you have a number of events which can be used to process the input as it comes in, or you can process the Properties of the Control once other code is running. One common pattern is to allow the user to input data into a number of TextBoxes, hit a button to run some action, and then process all of the input in one step after the button press. Another way to do the same thing would be to process and validate the input as it comes in, providing an error message if bad data was input.

For most of the Controls given above, you will find a **Value** property which gives either the Text of the Control or the selected state. The one exception to this is the ListBox which requires a little more work to get the Selection. For the ListBox, you need to iterate the items and check if the **Selected(index)** property of the ListBox is **True**.

TODO: add an example of using Value

Once you have the user input, it will typically be a **String** or a **Boolean**. To do something with these inputs, you will need to parse them into the desired types if not a string. The most common transformation is to parse a number from the string. This is done with **CInt** or **Cdbl** which will Convert a String into a Integer or Double. You will get an error if the string was not parseable. If you do not need a number, there are a couple of other “C” functions:

- **CBool**
- **CDate**
- **CErr**
- **TODO:** add others, and descriptions

Accessing the Excel Object Model

From a UserForm, you have full access to the Excel Object Model. This can be very handy if you are trying to access information from the UserForm to determine what information to show in the Form. It can also be helpful if you want to make changes to the underlying spreadsheet from a UserForm without leaving the form. Both of those options are very common and very easy to do with UserForms. In general, any code that can run without a UserForm present can be run with a UserForm. There are some limitations when it comes to the user's ability to select items with a Form visible, but you are not limited in calling the same commands from VBA (TODO: is that right?). The exception here is that if the form is `ShowModal = False` then the user is able to make selections while the form is visible.

There is no real limit to what you can do from a UserForm. A couple of examples to give you a feel:

- present a list of all open Workbooks so that the user can select which one that want to process
- Create a form that can process all of the selected Charts.
- Present a ListBox with the unique values from all of the AutoFilters that are active. Allow the user to selectively remove or change those filters without having to use the normal drop downs.

Accessing control Properties

The final piece of Forms programming is somewhat meta: allow the UserForm code to change the UserForm. There are a couple of obvious reasons you might want to do this:

- Change the position of the UserForm (center on start)
- Enable or disable a button or other control based on some input. You can extend this to making things visible or not as well.
- Change the text, format, or other visual detail of a Control based on some other state or user input.

TODO: add the code for centering a UserForm.

In addition to those simple concerns, you also have the ability to dynamically create controls on demand. This makes it possible to add/remove controls to the UserForm as needed. This can be helpful if you want to create a Control based on some property of the Worksheet but where you may not know how many times to do it in advance. For example, maybe you want to provide a ListBox with unique values for each column that was selected. In advance, you may not know the column count so you need to create ListBoxes on demand. This can be done with UserForm programming.

TODO: example to create a Control from scratch

overview of 9 UDFs

This chapter could focus on a couple aspects of UDFs. High level topics:

- Using them to return simple info that is hard to get otherwise (e.g. Range.Formula)
- Using them to hide complicated logic that could be done in a formula but would be a mess
- Using them to do things that are not possible otherwise

UDFs are a great way to extend Excel with some common features

Could include some examples of where this has been done in bUTL:

- String processing is much easier with UDFs instead of formulas (concatenation)
- Doing logic that might otherwise require an array formula
- UDFs are a great way to simplify formulas for conditional formatting
- UDFs are a great addition to a personal addin where the functionality is available without copying/changing formulas

Some technical points to hit:

- The pitfalls of using Ranges outside of the ones referred to
- Making a function Volatile and what that means

introduction to user defined functions (UDFs)

This chapter will focus on using VBA to create user defined functions (UDFs). This area of VBA is so-named because it allows you to add functions that are callable from the spreadsheet. Once you're familiar with VBA, you'll recognize that there is no difference between a normal VBA Function and a UDF. The only difference is that a Functions "becomes" a UDF once it is called from the spreadsheet. Having said that, UDFs are still incredibly powerful and can be an incredible time saver when working with a spreadsheet. The power of UDFs is that there are very few limitations to what you can do inside a UDF. This means that you can do complicated tasks from a single function call in Excel. Contrast this with the mess you get when doing complicated things with normal Excel functions.

This chapter will hit the major topics related to UDFs including:

- Debugging them
- Working with variable types, especially parameters but including outputs
- Limitations of UDFs – what you cannot do
- Limitations of UDFs in addins – must have the addin

-
- Different applications of UDFs
 - Simple things - string functions, etc.
 - Complicated things
 - Duplicating Excel functionality in a simpler package
 - Understanding volatility
 - Understanding Ranges and how they relate to your function being called
 - Hiding a VBA function from UDFs, and using the Option Private Module
 - Building more powerful UDFs with ExcelDna

getting started with UDFs

This section will focus on how to get started with UDFs. This will be a crude overview of VBA Functions and then a discussion of getting them to execute inside the Excel spreadsheet.

a primer on VBA Functions

Check the start of this book for a proper review of VBA Functions. The key points when using a function to execute as a UDF are:

TODO: link to section

- Function needs to be declared as Public
- Function needs to have a return type that can be processed in a cell (has a Value)
- Function needs to return something
- Function needs to be created in a code Module (not in a Worksheet or Workbook object)

Once you've met these criteria, you will be off and running. Typically a UDF will not work for one of those three reasons above. In particular, I regularly forget to declare the function Public and put it into a module. It's typically easier to remember to set the return type, but it is possible to forget to actually return something from the function

The best indicator of whether or not these steps have been followed is to type your UDF into a spreadsheet and see if it is recognized. Excel does a very good job of identifying valid functions and offering them in the autocomplete.

Tip: Sometimes it is difficult to remember the parameters that a UDF takes. You can either use the function input helper (TODO: add details about that) or you can use the shortcut CTRL+SHIFT+A which will populate

the names of the parameters into the UDF. Note that these are unlikely to be valid inputs to the function, so you will actually need to update the parameters. If you use descriptive names for the parameters (which you should!), this is a very helpful shortcut.

TODO: add an example of a very simple UDF here

some simple UDFs

This section will focus on the “simple” UDFs. It may sound silly, but there are a handful of surprisingly useful UDFs that are just a single line of code. In general, these UDFs are used to return some information about the spreadsheet that you’d prefer Excel simply have a function for. In later versions of Excel, some of these gaps have been filled (e.g. obtaining the formula for a cell) but sometimes these gaps still remain. In addition to one-liners, there are a large number of simple UDFs that exist to replace a more complicated Excel formula. These types of UDFs can be much easier to read and debug/test than a complicated array formula for example. The final group of UDFs that comes up frequently is string processing. Excel provides good functions for manipulating strings, but these can be a complete pain without the use of helper columns. A simple UDF can hold a variable which eliminates a lot of the need for helper columns via traditional formulas.

Before committing whole hog to UDFs being the best way to do things in Excel, it’s important to remember that there are downsides to UDFs. The most important is that if you want the UDF to live with the workbook (and not in an add-in) then you are required to save the workbook as macro enabled. This can be a deterrent to using them in certain environments. The other thing to remember is that UDFs can often be a crutch for not actually learning how to get the most out of Excel functions. It can be easy and tempting (especially for an experienced programmer) to start blasting through a spreadsheet with UDFs instead of learning how to do something “the Excel way”. Depending on your work setting and who else will see your workbooks/code, this may be a bigger issue for some people.

Common reasons for using a UDF

There are a number of consistent spots where I will use a UDF instead of fighting the Excel formulas. These typically fall into a couple of categories:

Excel formulas can be quite complicated/repetitive if need to store a variable. Certain valuable pieces of information about the cell or a Range are not available via functions. Some things are just much easier to do with VBA than with Excel.

examples of simple UDFs

TODO: add some examples here of different types

limitations of UDFs

This section will focus on the aspects of UDFs where you are limited. There are couple of key things to remember here:

- A UDF is not allowed to change the Workbook, Worksheet, or a Range – no side effects are allowed
- A UDF will only update if the cells it refers to change
- You can mark a UDF as Volatile, but this may create other problems (namely speed)
- UDFs are allowed to use global variables but you can wreck this process by having errors while they execute
- UDFs inside an addin can pollute a spreadsheet that might be used by someone without that addin
- You can debug a UDF but not by using the Evaluate Formula option that might be familiar to more people

no side effects

The biggest temptation of a UDF is one of the few things that is not allowed – you are not allowed to have a side effect from a UDF. This generally comes up when you want to change something about the Range that the UDF is referring to or being called from. You think: “I’d just love to color this cell red if the UDF detects some state while executing”. This thought comes up because it’d be nice to have the UDF update when called and even better if you can avoid dealing with conditional formatting. Alas, this is not allowed. The UDF must execute without making a change to the spreadsheet. This generally makes sense if you think about how Excel goes about calculating the spreadsheet. It makes a map of how cells are related and then proceeds to calculate the values in an order where each cell that depends on another is calculated in the precise order that is required. This process allows Excel to complete as fast as possible, without errors, and while using as many CPU cores as possible. If your UDF is able to change the spreadsheet after Excel has determined the order of calculations, then it becomes impossible to ensure that the spreadsheet is still correct. Because of this, Excel does not allow side effects from a UDF.

The other aspect of this limitation that comes up often enough in practice is that you cannot use a Worksheet function that modifies the spreadsheet even if you intend to undo that function. For example: I have attempted to use the AutoFilter inside a UDF in order to determine how many times some condition showed

up in a table. This is not allowed even though I intended to undo the AutoFilter before returning from my UDF. This limitation also applies to Copy/Paste and other common functions.

when does a UDF update

The next limitation to consider is that a UDF will only update when the Ranges it refers to are changed. This is related to the dependency tree described above. Excel will only call your UDF if one of the cells that it directly depends on it is updated. This is important because you have access to the entire Workbook inside a UDF so you can create a situation where your UDF *should* update something, but it doesn't because it does not know that it should have been updated. This is discussed later, but the quick way around this limit is to mark your UDF as Volatile. See the warnings later related to this.

A common example of when this sort of issue pops up is when you are using a reference to a Range inside the UDF that is computed only inside the UDF. For example, you want to do some statistics for a single Range that are dependent on a larger Range of data. You can write a UDF that takes the single cell as a parameter but then compute the larger Range inside the UDF without having to refer to it. Maybe that larger Range is a mess via normal Excel so you've skipped that step. Well, be aware that your UDF will only calculate for the even cell if the cell it refers to changes. This means that the larger group may change – and invalidate your current result – but if the single cell stays the same, then your UDF will not update that cell.

This same issue pops up if you are using properties of the Range that are not a part of the calculation model for Excel. That is, there are some changes which will not trigger a recalculation from Excel. These are typically related to using the formatting of a cell in a UDF. A very common example is returning the Range.Text from a UDF so that you can get the value exactly as it is displayed in the spreadsheet. If you change the format of the cell, you are not guaranteed to have the UDF called updating your UDF value.

using Application.Volatile

Mentioned above, there is one surefire way to ensure that your UDF will be called whenever there is a change anywhere on the spreadsheet: mark the function as Volatile. This is done by calling Application.Volatile somewhere in your UDF. TODO: is this right? Once you have made this call, your UDF will be called anytime a calculation is done. This also means that anything that depends on your cell will be recalculated every time. There is a huge upside to using Volatile UDFs in certain instances: you are guaranteed that they represent the correct value. The downside is that your UDF is being called constantly which means that if it is slow, your entire spreadsheet will be slow. If your UDF is littered across 10,000 cells, it will be run

10,000 times even if only a single cell changed. It is easy to underestimate how much this can slow down a Workbook. Having said that, sometimes speed is not a factor and you just want things to be correct.

There are other functions (INDIRECT and OFFSET are the main ones) in Excel that are volatile, so it is not some awful thing to do necessarily. You should mark something as Volatile however only as a last resort or possibly as a first resort if you're just punching something out.

To avoid using Volatile, you may be able to have your UDF take an additional parameter to ensure that it is on the calculation chain of all the cells it depends on. Note: you don't actually have to use the parameters for anything, but if they appear in the UDF call, it will force Excel's calculation tree. Continuing with the statistic example from above, if you know that all of the data that could change is in columns B and C, you can simply send B:C in as a parameter to the UDF. This ensures that a change in those columns will force the UDF to call. You can then continue to compute the Range using your more complicated logic. This is somewhat wasteful and means you have extra parameters which don't do anything, but it can be a cleaner (and faster) solution than using Volatile.

beware of global variables

VBA allows you to declare a variable outside of any Sub or Function definition. These are typically called global variables because they can be accessed from any code. This means that you can create some variables in a Sub and then use them in subsequent UDF calls. A good example is loading up a database of information and then using that information inside the UDF. This can be nice because then you do not have to load the data every time you call the UDF. I've used this effectively when doing unit conversions with UDFs.

The downside to this approach is that it seems to be relatively easy to corrupt those global variables if you have errors while the UDF runs. I've had it happen where that loaded database becomes corrupted somehow and then all of the dependent cells start to fail when their UDF is called. This type of error can be quite difficult to track down because it may not be obvious why the variable was corrupted.

beware of UDFs in addins

A personal addin is a great way to organize helper code without constantly creating macro-enabled files to use the code. For Subs this works great because there is no lasting trace that a Sub was run, at least in terms of code in the file. For a UDF however, your UDF call will be a part of the spreadsheet. This does not force the spreadsheet to be a macro-enabled one – which is great – but it does mean that anyone using the

spreadsheet needs access to the UDF code. This creates a problem when you get comfortable using UDFs in an addin but then save the workbook with them in there. You have effectively “polluted” the workbook with addin UDF names which may or may not be available to others. This is fine if the addin truly is critical to the workbook, but it can create a mess for others if you’re using UDFs for your own help and make a spreadsheet that others cannot use.

The solution to this problem is to simply save the UDF as a Module in the spreadsheet, but this requires you to save the Workbook as macro enabled.

A rule I like to follow is simply: if I know that a UDF is required for the spreadsheet and that UDF is currently in an addin, I force myself to move the code into the Workbook and save as macro enabled. This can be a pain, but it’s all too common that a Workbook is saved with a UDF from an addin, that addin changes or becomes unavailable, and now your Workbook is broken. It’s best to avoid this scenario especially if you work with others who are not macro savvy.

debugging UDFs is different

Most folks are familiar with the “Evaluate Function” feature of Excel which will help you walk through a function’s evaluation in the order that Excel evaluates things. This can be incredibly helpful for array formulas where it’s not always obvious the order Excel will do things in. Your UDF will also be evaluated in that feature, but it will not step through the logic of your UDF. This might seem obvious, but it’s worth mentioning. IF you want to debug the logic of your addin, you need to set a breakpoint and actually debug the code. See the later section on this for the details.

TODO: add link to that section

managing the parameters and types of UDFs

This section will focus on a topic that is quite nuanced but can have a large impact on how reusable your UDF code is. The focus here is on how to specify the type of the parameters and possibly the return of the UDF.

The reason things get tricky is that Excel is able to feed a wide range of object types to a UDF depending on how it was called. The common types to see are:

- Range
- Array/Variant

-
- Double/Number
 - String
 - Date
 - Error

The most common ways to call a UDF are

- Use a Range reference UDF(A1:B2)
- Use the result of some other operation UDF(5*A2). This can result in different object
 - Array formula gives an array
 - Math might give a number
 - String formulas will give a string
 - IF or CHOOSE might allow for multiple options depending on the result

Given this wide range of choices, it's important to consider how you intend for your UDF to be called and what types of inputs you want to be able to handle. You can choose to be as loose or as restrictive as you want on the parameter type, but this will have an impact on usage. If you go the loose route, you can call everything a Variant, but then you lose the utility of Intellisense as you are programming. If you go the strict route, you gain Intellisense, but might make your UDF fail on a simple case that it should be able to process.

As an example, let's say you've written a UDF that simply squares the number that it is fed. If you specify the parameter of this as a Range, your code will work fine with usages like UDF(A1), etc., but it will fail if someone sends in the result of math UDF(5*A1). This is odd because assuming that A1 is a number, there is no reason that you cannot square the result of that. Instead however, you will get an error that the result of that math (which is a Double) cannot be converted to a Range and your code will error out. For a simple example like this, it makes the most sense to declare the parameter as a Variant and just rely on the Value being correct.

TODO: add code for that example

Things are fixed simple in that case, but it quickly becomes an issue when you want to handle different types of input. Maybe you are making a function that will concatenate an array of strings together. What happens when you only get a single string as a String instead of an Array containing Strings? Most likely, your code will fail in this instance, unless you've built in the proper checks on the type. In this case, you will likely need to take a parameter of Variant and then do the checking to see how to handle it.

TODO: add an example of string concat code that works

The most common spot to see this sort of issue is when deciding whether to deal with a type of Range or

Variant (to handle an array). It is nice to work directly with Ranges and avoid the Variant, but this will make your code weak against someone who wants to use an array formula to call your UDF. It typically does not take much work to process an Array, but it helps to design things from the start like that.

TODO: add before example of UDF using Range TODO: add after example of that UDF using a Variant/Array instead of the Range

a note on return types

The same thing can happen on the return side of the equation, but it is typically less of a problem. The main issues on the return side are returning arrays and dealing with Strings. If you want your UDF to work as an array formula, you can simply return an array and it will work. If that array is only a single cell, then it will look the same as a non-array formula.

Another issue is when working with Strings. If you return a string from a UDF, it will be formatted as Text instead of General. TODO: is that true? This can have intended consequences as Excel tends to treat Text differently when it is then sent to other functions. The most common example is that a number stored as text will not be available for normal math operations.

You can avoid this by returning Variant but it can become an issue when you want a Function to work as a UDF and as a normal VBA Function. You might have a good reason to use a specific return type on the VBA side of things, but then Excel may not handle that the way you want (if using a String). Or, going the other way, you may have a UDF that works great because Excel can treat a single entry array as a single cell, but that becomes complicated when you call the UDF from another VBA location and then have to deal with a single number versus an array.

complicated UDFs

One of the great advantages of UDFs is that you give yourself full access to all of VBA while still executing within the spreadsheet. There are some limits to this power, but, in general, you are able to do some very powerful stuff in the same interface that you normally do a [SUM](#). To take advantage of this power, you need to be aware that these things are possible and then consider taking a shot at it.

Some of the more complicated areas where you will want to write a UDF include:

- Using Range information from cells not related to the parameters
- Accessing the FileSystem

Related to the Range, you have full access to all of the Workbooks and Worksheets that are available in VBA. This means that you can combine a large amount of data in VBA and then output it to a UDF return. Where this becomes useful is when you want to look at the metadata of a Range of Worksheet. Until Excel 2013, most of this information was simply not available without VBA. Post 2013, you are able to use the `CELL` function (TODO: is this right). Some of the more useful things here are to use the formatting of a cell (e.g. return the background color) or the display value (i.e. `Range.Text`). These UDFs can be great for either long term usage or for a quick throwaway to get information into the spreadsheet. When doing the latter, there is essentially no difference between using a UDF and running through the cells using a normal Sub. The main reason you might use a UDF is if the cells you want to target are not easy to identify in VBA.

Other possible UDFs allow you to access the file system and possibly return information from there. One example would be to return the size of a file in KB given a file name. Really, you could go get any information you want. Again, this type of UDF can be easily done as a UDF or just as a Sub that runs through a Range as an input.

When considering whether or not to use a UDF or a Sub, consider the following:

- A UDF will update automatically when the parameters to it change (or always if marked as Volatile). This is the key differentiator.
- A Sub can run without embedding itself into a spreadsheet. This is key if you need to save the spreadsheet with your information without a link to your code. This is a moot point if your UDF lives in an XLSM file but starts to matter for an add-in. You can also do a copy/paste values if you want to remove the UDF.

TODO: consider adding more here or refining this section

debugging UDFs

Debugging a UDF is really the same as debugging normal code except you need to understand when your code will be called and hence, what you may be debugging. The simplest way to think about debugging a UDF is with an empty spreadsheet. In this example, once you type your UDF into the spreadsheet, Excel will execute the code and you can debug it via a breakpoint. This is simple.

For a larger spreadsheet however, you are very likely to use your UDF more than once while only having a problem with a specific instance of it. Let's say your UDF does some fancy statistics but cannot handle certain types of inputs. You can see that your code is throwing an error with a `#VALUE!` output. If you add a breakpoint to the UDF, then you risk having to debug a large number of successful calls before your bad one happens.

There are a couple of approaches to deal with this:

- Edit a formula for the cell you want with a breakpoint set in the debugger. Excel will execute that “new” formula first which will be the one of interest.
- Right a quick If statement to check if the teh Caller’s address is a specific cell.

The first example is easy enough to understand and si the typical approach for debuggin a UDF. It’s a bit of a pain because your breakpoint will stay in place and may be hit several times later. To get around this, you can siwtch over to manual calculation to avoid all the other cells calcualting. TODO: is that right?

The second approach works well when you have a UDF in several place but where only one of them is causing an erorr. You can add a temporary statement at the top to check for the Calller address and then set a breakpoint inside there. ocne it’s hit, you know you are debugging the right call and can then step through teh code. You can do the same approach to check for the incoming value or really anythign else that is unique to the problematic cell. The nice thing ehre is that if you can figure out what statement to use for the breakpoint, you will ahve n aidea of which condiditons may cause the problem.

TODO: how are runtime errors handled here? any way to get them thrown with a prompt.

ConcatArr.md

```
1 Public Function ConcatArr(rngCells As Variant, strDelim As String) As String
2     Dim cellCount As Long
3
4     cellCount = UBound(rngCells, 1)
5
6     Dim arrValues As Variant
7     ReDim arrValues(1 To cellCount)
8
9     Dim index As Long
10    index = 1
11
12    Dim rngCell As Variant
13    For Each rngCell In rngCells
14        arrValues(index) = rngCell
15
16        index = index + 1
17    Next
18
```

```
19 ConcatArr = Join(arrValues, strDelim)
20 End Function
```

ConcatRange.md

```
1 Public Function ConcatRange(rngCells As Range, strDelim As String) As String
2     Dim cellCount As Long
3
4     cellCount = rngCells.CountLarge
5
6     Dim arrValues As Variant
7     ReDim arrValues(1 To cellCount)
8
9     Dim index As Long
10    index = 1
11
12    Dim rngCell As Range
13    For Each rngCell In rngCells
14        arrValues(index) = rngCell
15
16        index = index + 1
17    Next
18
19    ConcatRange = Join(arrValues, strDelim)
20 End Function
```

RandLetters.md

```
1 Public Function RandLetters(ByVal letterCount As Long) As String
2
3     Dim letterIndex As Long
4
5     Dim letters() As String
6     ReDim letters(1 To letterCount)
7
8     For letterIndex = 1 To letterCount
```

```
9         letters(letterIndex) = chr(Int(Rnd() * 26 + 65))
10     Next
11
12     RandLetters = Join(letters(), "")
13
14 End Function
```

overview of 10 building an addin

The addin chapter can be a real difference maker. Making an addin is a great way to bring together a large number of related features that would be a pain to keep together anyways.

Some topics to hit:

- The advantages of always having an addin available to save new code into
- How to actually create an addin (the actual steps of saving it)
- Working with the Ribbon
- Adding keyboard shortcuts to the addin (via events)
- Managing the source code for an addin?

In addition to the VBA addin, it would be good to discuss the other options for extend Excel.

Include a section about Excel DNA and creating more powerful addins over there?

introduction to creating an addin

This chapter will focus on creating an addin for Excel using VBA. There are other ways to create an addin but using VBA is simple because it can be done entirely from Excel and the Visual Basic Editor. The main distinction between an addin and other VBA code is that an addin is meant to be available to all open Workbooks without having to put the code inside a Workbook. This can be a very nice thing to have if you are regularly do the same or similar operations across different Workbooks. The alternative to an addin is often to maintain a library of code that you regularly export/import into macro enabled files as needed. This can create a mess as you change code in one file but not in another. The alternative also typically requires you to put the code inside a the Workbook and make it macro enabled. For certain applications, this is a non-starter. The one other alternative to a true addin is to create a Workbook that contains the code you want, and then you can open that file and execute the code in the context of whatever other files are

open. This works, and creating an addin can be viewed as the logical conclusion of this approach. More than the logical conclusion, this is actually the first step for creating an addin.

When considering whether or not to create a proper addin with your code, consider the following:

- An addin provides a nice package for helper code and UDFs that might be used in multiple places
- An addin has easy access to the Ribbon and can create its own Ribbon tab
- An addin can be put in a central location and used as a repository of code for an organization (works best if the file is read-only)

Item 1 in the list above is typically enough of a reason to consider creating an addin. A common example of an addin is as a personal repository of VBA code. This typically replaces the use of the Personal Workbook, which I have never found to work well.

When considering a personal addin, one of the biggest upsides is that you can always open the VBE and have immediate access to your library of code. This makes it easy to make edits and save the new addin. Immediately, your updated code is available for future use in all your Workbooks.

There are a couple of downsides related to addins:

- UDFs from an addin require that anyone opening the spreadsheet has the addin loaded
- For code in a single Workbook, it is often easier to simply use a macro enabled Workbook and save the code directly there
- Some folks are highly resistant to “installing an addin” but will happily open a XLSM file. These are equivalent in the case of opening an addin, but the hesitation still exists.

Point 2 above is worth expanding on. Sometimes it’s tempting to add code to an existing addin that make sense only in the context of a single file. This works well if you and everyone else have the addin. This starts to become a nuisance when you are constantly going through your addin to find code that should have been place in a Workbook to start. The cleaner way to store code that may be useful later is to place a copy of it in a personal addin. This ensures that the original code is always available in the Workbook and that future updates to the code don’t break the original application.

creating an addin

Creating an addin is a relatively simple process. You start with a normal XLSM macro enbaled file. From there, you save it as the add-in type (XLAM). That’s it.

If you want to get more complicated, there is a property in teh VBE that can be toggled to change the addin status. (TODO: add picture of that). You would only need to change that flag if for some reason you wanted

to save something back to a normal XLSM workbook without changing the extension.

There is one additional process that can be done to change how the addin is created is that is if you are modifying the Ribbon for your addin. To do that, you will need to manually edit the XLAM file and change a file within it to add Ribbon support. You can do this manually or you can use a tool to help you out. Check the later section for details on that process.

specific aspects to addin development

Depending on the addin that you are creating, you may expect for it to have a handful of features available. In general, those types of features include keyboard shortcuts, special forms or user prompts, and possibly automatic features that fire depending on the user's action or the state of the workbook or Application.

Keyboard Shortcuts

The simplest thing to do is to add keyboard shortcuts to your addin. There are two ways to do that:

- Open up the Macros form on the Developer tab. You can then hit “options” for a given Sub and assign a keyboard shortcut (TODO: add picture of this)
- That approach can sometimes be a pain to edit later, so you can also add code to your addin to add the shortcut.

The latter approach is nice because you can easily change the shortcut or the calling method. For addins, I will nearly always take the latter approach since it is much easier to deal with later. For XLSM workbooks, I will do the former since it is easier to change from a workbook.

If you want to add the keyboard shortcut using code, use the code below. Ideally, you would put this in a Workbook_Open event that is called when the workbook opens. You can also use this approach to add/remove shortcuts depending on user input.

```
1 Public Sub SetUpKeyboardHooksForSelection()  
2  
3  
4     'SHIFT =      +  
5     'CTRL  =      ^  
6     'ALT   =      %  
7  
8     'set up the keys for the selection mover
```

```
9 Application.OnKey "^%{RIGHT}", "SelectionOffsetRight"
10 Application.OnKey "^%{LEFT}", "SelectionOffsetLeft"
11 Application.OnKey "^%{UP}", "SelectionOffsetUp"
12 Application.OnKey "^%{DOWN}", "SelectionOffsetDown"
13
14 'set up the keys for the indent level
15 Application.OnKey "+^%{RIGHT}", "Formatting_IncreaseIndentLevel"
16 Application.OnKey "+^%{LEFT}", "Formatting_DecreaseIndentLevel"
17
18 End Sub
```

User Forms

One of the nice features of an addin are adding custom forms to provide the user with a better experience. Creating a UserForm in VBA is dead simple, and this is the best bang for your buck in terms of creating a professional looking product. The simplest of forms with the simplest of features can save the end user hours and hours of time (I've seen it happen).

The nice thing here is that creating a UserForm in an addin is not any different than creating them normally. You simply create the UserForm. The only extra step is that you need to manage how/when the form is created and what information it has access to. Typically this is done by adding a button or using a keyboard shortcut. The only other issue is that you need to be aware of which Workbook or Worksheet is active when opening a UserForm if you are using ActiveSheet or ActiveWorkbook for anything. In general, inside an addin, you need to be careful with these commands since it is not always obvious that the ActiveXXX is the one you want to access.

Helpful Commands

There are a couple of commands that exist outside of addins that become far more useful inside the addin. They are included below for reference:

- `ThisWorkbook` refers to the workbook that contains the code being executed. This is the surefire way to refer to the XLAM file that is running instead of the ActiveWorkbook. In general, your addin will never be the ActiveWorkbook. This becomes relevant if your addin workbook contains sheets of data that may need to be accessed during runtime. You would use `ThisWorkbook` to refer to those sheets.

-
- TODO: add any other commands that are addin specific

Other functionality

The other functionality that you can add is related to Events. You have great power when it comes to listening to events and triggering various actions. The real difficulty is deciding what is an appropriate use of that power. Namely, when will you create an experience that benefits the user versus creating a very confusing workbook that is prone to breaking?

Before diving into what events can do, it's worth noting that potential downsides of using them:

- They can be quite finicky sometimes. That is, using events adds a layer of complexity that tends to just complicate Excel and VBA. I don't have a technical explanation, but there seem to be a number of bugs that creep out of the dark once you start really using events.
- Your user can disable events at will and it can be quite difficult to determine when that was done. This is done with `Application.EnableEvents = False`.
- Events are triggered all the time for all sorts of reasons. If you are doing a lot of checking in Events, you will dramatically slow down the workbook.

With all of those warnings, there is nothing wrong with using Events. They generally do what you want and can be quite powerful. I add the caveats only because I have seen them ruin an otherwise working workbook. That complexity gets amped up a level when your Event code is inside an addin instead of the main workbook.

To really make the most of Events, you are going to need to use Class Modules. The reason is that your Events need to "latch on" to the host workbooks or worksheets, and the only way to do that is by using Class Modules. Normally, outside of an addin, you can simply open up the relevant VBA object (Workbook or Worksheet) and add the event code there. For an addin, you cannot add that code outside of the addin so you are in a bind. How then can you hook onto the Event? Fortunately, VBA makes this possible with the `WithEvents` command inside of a Class Module.

TODO: provide a concrete example of using this code

UI features for addins, Ribbon, toolbars, UserForms

There are a number of UIs that can be provided for an addin. The most common involve using the Ribbon or providing UserForms (typically accessible from a keyboard shortcut). Those two approaches will be discussed

in detail. It is also worth mentioning that if you are going to support Excel 2007 and before, that the Ribbon did not exist back then. For those prior versions of Excel, the interfaces were built using toolbars and menu items. That's before my day, so I'll just say that if you use that code today, it will show up in the Ribbon. If you need to support those versions of Excel, you would do well to find a different book.

the Ribbon

When using the Ribbon, there are a couple of items to consider:

- Do you want your UI to show up in an existing tab or on your own?
- How interactive do you want your UI to be? This can range from simple buttons that trigger actions to text boxes and other more interactive features that are able to detect user input and respond accordingly.
- How do you prefer to edit the file? How fast do you want your development cycle to be with respect to the UI?

For the first point, this is a simple preference. For a given addin it may make sense to simply put the buttons and other access on an existing tab (Developer and Data are popular!) and provide that level of access. For an addin that has a dedicated purpose independent of other Excel features, it starts to make sense to add your own tab exclusively for your addin. This is good for helping your users find your features. It can also be more consistent in terms of keyboard shortcuts. If you are going to modify an existing tab, be absolutely certain that you verify that the keyboard shortcuts work as expected. There is nothing worse than having an addin break the ALT+A+R+Y shortcut which is supposed to reapply an autofilter. It is not fun when that shortcut becomes ALT+A+R+Y2. Seriously?

For the second point, you will need to consider the average user and their expectations. Keep in mind that the default Excel Ribbon includes a number of locations where user input is collected and used beyond a simple button. This includes things like some number input (font size, page layout) and other drop downs. There is a willingness for Excel users to use these features where it makes sense. For what it's worth, from the Excel VBA point of view, it is much simpler to not try and collect user input. This can be done (TODO: add examples), but the effort here is typically not worth the user experience. If you choose to go this route, I would highly recommend using drop downs and other inputs that provide some automatic filtering of user input. Trying to validate user input off the Ribbon is a pain and does not provide a good experience. Having said that, if you are designing for power users, you can build a very slick interface in the Ribbon that is unmatched.

The final point gets down to the nitty gritty of actually editing the Ribbon. The problem is that the Ribbon

is defined in a file inside your XLAM file and is not editable from any part of the VBE or Excel interface. This means that it is a real pain to edit the Ribbon definition in the same way that you can edit the other VBA code. I have typically taken the approach of using a button on the Ribbon to launch a form that exists in VBA. That form can then be edited without having to touch the Ribbon definition. This sounds trivial, but it can make a huge difference if you are designing an add-in that has a lot of possible interactivity; it is very difficult to edit the Ribbon in real time. Having said that, there is one add-in that makes this process much more manageable. It is from Andy Pope (TODO: add link) and works great for building out the interface. Even using that add-in, it is a pain to add the callback necessary to tie the Ribbon to VBA. Don't be dissuaded from creating a nice Ribbon UI, but realize that it takes time and effort and attention to detail to properly detail out the Ribbon UI aspects.

editing the Ribbon Note that the Ribbon is defined in an XML file inside your XLAM file. Remember that an XLAM file is simply a ZIP file of a bunch of different folders. By default, the Ribbon definition is not included and you must add the folder and file. To do this, simply create the `customUI` folder and then create a XXX XML file inside there. This file will define the specific changes you are making to the Ribbon.

callbacks Once you have the Ribbon XML set up, you will be defining callbacks that need to actually exist in the VBA code. I always like to create a `Ribbon` module in the XLAM file which is solely responsible for callbacks. This is nice for larger add-ins with a large number of callbacks because it provides a single place. It also avoids debugging errors later when you accidentally put some critical code into a callback and forgot to check that out.

The callbacks take an odd signature. I always use Andy Pope's add-in or copy a previous one. I have very seldom used the parameters in the callback for accessing the Ribbon information. My approach has always been to avoid extra interactivity with the ribbon. I have done it before, and it works, but the problem is that it is just not intuitive to do it that way. It is much easier to add a keyboard shortcut which shows a UserForm than to attempt to get the user to focus on the Ribbon (using the keyboard or mouse) and then provide the best info.

UserForms

If you are going to use UI features within your add-in, you are going to use UserForms. They provide the cleanest and easiest interface for the vast majority of automation and other tasks. The one exception to using a UserForm is when you can get by with a simple `InputBox`. You should always prefer the `InputBox`

because the procedure for calling them and obtaining a value is dead simple. Also, the InputBox is the best way to ask the user for a Range input via selection. You can technically use the `RefEdit` control, but that control is very sensitive when it works.

If you are building a UserForm, there is very little that is different from a normal UserForm. The only thing to be aware of are the logistics of creating, showing, and hiding the UserForm. I have previously tried to keep an instance of a given form live in order to use the previous values. This has worked well inside a single Workbook but seems to be very finicky when working across multiple Workbooks. The procedure here is very simple:

```
1 Dim frm as UserForm
2 Set frm = New UserForm
3
4 frm.Show
```

The code above is all that is required to create a new instance of a form and show it to the user. From there, the code is the same as before: you simply create the form and call the various Subs you want. One thing which is helpful is to hide the form when you are done. This is done with the `Unload Me` command.

One other item to be aware of is that the default UserForm is set to `ShowModal = True` which applies the modal property. A “modal” dialog is one who steals focus from any other elements and must be dealt with before you can go back to your previously focusable elements. This is often good for certain workflows where you do not want the user to change the underlying spreadsheet while you collect their input. There are other instances however where it makes sense to allow the user to change the active Workbook, Worksheet, or Selection and then interact with your form. To allow for this behavior, set `ShowModal = False`. This will allow your form to exit even when the user clicks off and interacts with the spreadsheet again. This is a real game changer when you are working with code that operates on the current selection. You are then able to leave your form up while the user changes the selection. From there, they are able to call the code they want on the objects they want. I have used this technique to great effect when working with Charts: allow the user to select their charts and then hit a button.

overview of 11 utility code

This chapter might be a dumping ground for useful code that is worth being able to reference. Some things to include here:

- Code to work through the selection on a Chart

-
- The RangeEnd function to quick get the end of a Range
 - Some string processing code?
 - The code to work with split values
 - Code to convert a 2D array of values to 1D
 - GetOrCreateWorksheet which gives you a valid object regardless of what existed
 - CreateNextSheet which increments a name as needed
 - Creating a Chart based on the XValues, Values, and Name (and order).
 - CopyResize command which is used to replicate Copy/PasteValues without using the Clipboard

ColorInputs.md

```
1 Public Sub ColorInputs()  
2  
3     Dim targetCell As Range  
4     Const FIRST_COLOR_ACCENT As String = "msoThemeColorAccent1"  
5     Const SECOND_COLOR_ACCENT As String = "msoThemeColorAccent2"  
6     'This is finding cells that aren't blank, but the description says it  
7     'should be cells with no values..  
8     For Each targetCell In Selection  
9         If targetCell.Value <> "" Then  
10            If targetCell.HasFormula Then  
11                targetCell.Interior.ThemeColor = FIRST_COLOR_ACCENT  
12            Else  
13                targetCell.Interior.ThemeColor = SECOND_COLOR_ACCENT  
14            End If  
15        End If  
16    Next targetCell  
17 End Sub
```

CombineAllSheetsData.md

```
1 Public Sub CombineAllSheetsData()  
2  
3     'create the new wkbk and sheet  
4     Dim targetWorkbook As Workbook
```

```
5 Dim sourceWorkbook As Workbook
6
7 Set sourceWorkbook = ActiveWorkbook
8 Set targetWorkbook = Workbooks.Add
9
10 Dim targetWorksheet As Worksheet
11 Set targetWorksheet = targetWorkbook.Sheets.Add
12
13 Dim isFirst As Boolean
14 isFirst = True
15
16 Dim targetRow As Long
17 targetRow = 1
18
19 Dim sourceWorksheet As Worksheet
20 For Each sourceWorksheet In sourceWorkbook.Sheets
21     If sourceWorksheet.name <> targetWorksheet.name Then
22
23         sourceWorksheet.Unprotect
24
25         'get the headers squared up
26         If isFirst Then
27             'copy over all headers
28             sourceWorksheet.Rows(1).Copy targetWorksheet.Range("A1")
29             isFirst = False
30
31         Else
32             'search for missing columns
33             Dim headerRow As Range
34             For Each headerRow In Intersect(sourceWorksheet.Rows(1),
35                 sourceWorksheet.UsedRange)
36
37                 'check if it exists
38                 Dim matchingHeader As Variant
39                 matchingHeader = Application.Match(headerRow,
40                     targetWorksheet.Rows(1), 0)
```

```

41         If IsError(matchingHeader) Then targetWorksheet.Range("A1
42             ").End(xlToRight).Offset(, 1) = headerRow
43     Next headerRow
44 End If
45
46     'find the PnPID column for combo
47     Dim pIDColumn As Long
48     pIDColumn = Application.Match("PnPID", targetWorksheet.Rows(1),
49         0)
50
51     'find the PnPID column for data
52     Dim pIDData As Long
53     pIDData = Application.Match("PnPID", sourceWorksheet.Rows(1), 0)
54
55     'add the data, row by row
56     Dim targetCell As Range
57     For Each targetCell In sourceWorksheet.UsedRange.SpecialCells(
58         xlCellTypeConstants)
59         If targetCell.Row > 1 Then
60
61             'check if the PnPID exists in the combo sheet
62             Dim sourceRow As Variant
63             sourceRow = Application.Match( _
64                 sourceWorksheet.Cells(targetCell.Row, pIDData)
65                 , _
66                 targetWorksheet.Columns(pIDColumn), _
67                 0)
68
69             'add new row if it did not exist and id number
70             If IsError(sourceRow) Then
71                 sourceRow = targetWorksheet.Columns(pIDColumn).Cells(
72                     targetWorksheet.Rows.Count, 1).End(xlUp).Offset(1)
73                     .Row
74                 targetWorksheet.Cells(sourceRow, pIDColumn) =
75                     sourceWorksheet.Cells(targetCell.Row, pIDData)
76             End If
77
78             'get column
79             Dim columnNumber As Long

```

```
73         columnNumber = Application.Match(sourceWorksheet.Cells(1,
74             targetCell.Column), targetWorksheet.Rows(1), 0)
75
76         'update combo data
77         targetWorksheet.Cells(sourceRow, columnNumber) =
78             targetCell
79
80     End If
81 Next targetCell
82 End If
83 Next sourceWorksheet
84 End Sub
```

ConvertSelectionToCsv.md

```
1 Public Sub ConvertSelectionToCsv()
2
3     Dim sourceRange As Range
4     Set sourceRange = GetInputOrSelection("Choose range for converting to CSV
5         ")
6
7     If sourceRange Is Nothing Then Exit Sub
8
9     Dim outputString As String
10
11     Dim dataRow As Range
12     For Each dataRow In sourceRange.Rows
13
14         Dim dataArray As Variant
15         dataArray = Application.Transpose(Application.Transpose(dataRow.Rows.
16             Value2))
17
18         'TODO: improve this to use another Join instead of string concats
19         outputString = outputString & Join(dataArray, ",") & vbCrLf
20
21     Next dataRow
22
23     Dim myClipboard As MSForms.DataObject
```

```
22     Set myClipboard = New MSForms.DataObject
23
24     myClipboard.SetText outputString
25     myClipboard.PutInClipboard
26
27 End Sub
```

CopyCellAddress.md

```
1 Public Sub CopyCellAddress()
2
3
4     'TODO: this need to get a button or a keyboard shortcut for easy use
5     Dim myClipboard As MSForms.DataObject
6     Set myClipboard = New MSForms.DataObject
7
8     Dim sourceRange As Range
9     Set sourceRange = Selection
10
11     myClipboard.SetText sourceRange.Address(True, True, xlA1, True)
12     myClipboard.PutInClipboard
13 End Sub
```

CutPasteTranspose.md

```
1 Public Sub CutPasteTranspose()
2
3
4     '#####Still Needs to address Issue#23#####
5     On Error GoTo errHandler
6     Dim sourceRange As Range
7     'TODO #Should use new inputbox function
8     Set sourceRange = Selection
9
10     Dim outputRange As Range
11     Set outputRange = Application.InputBox("Select output corner", Type:=8)
```

```
12
13 Application.ScreenUpdating = False
14 Application.EnableEvents = False
15 Application.Calculation = xlCalculationManual
16
17 Dim topLeftCell As Range
18 Set topLeftCell = sourceRange.Cells(1, 1)
19
20 Dim topRow As Long
21 topRow = topLeftCell.Row
22 Dim leftColumn As Long
23 leftColumn = topLeftCell.Column
24
25 Dim outputRow As Long
26 Dim outputColumn As Long
27 outputRow = outputRange.Row
28 outputColumn = outputRange.Column
29
30 outputRange.Activate
31
32 'Check to not overwrite
33 Dim targetCell As Range
34 For Each targetCell In sourceRange
35     If Not Intersect(sourceRange, Cells(outputRow + targetCell.Column -
        leftColumn, outputColumn + targetCell.Row - topRow)) Is Nothing
        Then
36         MsgBox ("Your destination intersects with your data. Exiting.")
37         GoTo errHandler
38     End If
39 Next
40
41 'this can be better
42 For Each targetCell In sourceRange
43     targetCell.Cut
44     ActiveSheet.Cells(outputRow + targetCell.Column - leftColumn,
        outputColumn + targetCell.Row - topRow).Activate
45     ActiveSheet.Paste
46 Next targetCell
47
```

```
48 errorHandler:
49     Application.CutCopyMode = False
50     Application.ScreenUpdating = True
51     Application.EnableEvents = True
52     Application.Calculation = xlCalculationAutomatic
53     Application.Calculate
54
55 End Sub
```

FillValueDown.md

```
1 Public Sub FillValueDown()
2
3     Dim inputRange As Range
4     Set inputRange = GetInputOrSelection("Select range for waterfall")
5
6     If inputRange Is Nothing Then Exit Sub
7
8     Dim targetCell As Range
9     For Each targetCell In Intersect(inputRange.SpecialCells(xlCellTypeBlanks
10         ), inputRange.Parent.UsedRange)
11         targetCell = targetCell.End(xlUp)
12     Next targetCell
13 End Sub
```

ForceRecalc.md

```
1 Public Sub ForceRecalc()
2
3     Application.CalculateFullRebuild
4
5 End Sub
```

GenerateRandomData.md

```
1 Public Sub GenerateRandomData()  
2  
3     Const NUMBER_OF_ROWS As Long = 10  
4     Const NUMBER_OF_COLUMNS As Long = 3 '0 index  
5     Const DEFAULT_COLUMN_WIDTH As Long = 15  
6  
7     'Since we only work with offset, targetcell can be a constant, but range  
8     constants are awkward  
9     Dim targetCell As Range  
10    Set targetCell = Range("B2")  
11  
12    Dim i As Long  
13  
14    For i = 0 To NUMBER_OF_COLUMNS  
15        targetCell.Offset(, i) = chr(65 + i)  
16  
17        With targetCell.Offset(1, i).Resize(NUMBER_OF_ROWS)  
18            Select Case i  
19                Case 0  
20                    .Formula = "=TODAY()+ROW()"  
21                Case Else  
22                    .Formula = "=RANDBETWEEN(1,100)"  
23                End Select  
24  
25                .Value = .Value  
26            End With  
27        Next i  
28  
29        ActiveSheet.UsedRange.Columns.ColumnWidth = DEFAULT_COLUMN_WIDTH  
30    End Sub
```

OpenContainingFolder.md

```
1 Public Sub OpenContainingFolder()
```

```
2
3     Dim targetWorkbook As Workbook
4     Set targetWorkbook = ActiveWorkbook
5
6     If targetWorkbook.path <> "" Then
7         targetWorkbook.FollowHyperlink targetWorkbook.path
8     Else
9         MsgBox "Open file is not in a folder yet."
10    End If
11
12 End Sub
```

PivotSetAllFields.md

```
1 Public Sub PivotSetAllFields()
2
3     Dim targetTable As PivotTable
4     Dim targetSheet As Worksheet
5
6     Set targetSheet = ActiveSheet
7
8     'this information is a bit unclear to me
9     MsgBox "This defaults to the average for every Pivot table on the sheet.
10         Edit code for other result."
11     On Error Resume Next
12     For Each targetTable In targetSheet.PivotTables
13         Dim targetField As PivotField
14         For Each targetField In targetTable.DataFields
15             targetField.Function = xlAverage
16         Next targetField
17     Next targetTable
18 End Sub
```

SeriesSplit.md

```

1 Public Sub SeriesSplit()
2
3     On Error GoTo ErrorNoSelection
4
5     Dim selectedRange As Range
6     Set selectedRange = Application.InputBox("Select category range with
7         heading", Type:=8)
8     Set selectedRange = Intersect(selectedRange, selectedRange.Parent.
9         UsedRange).SpecialCells(xlCellTypeVisible, xlLogical + xlNumbers +
10         xlTextValues)
11
12     Dim valueRange As Range
13     Set valueRange = Application.InputBox("Select values range with heading",
14         Type:=8)
15     Set valueRange = Intersect(valueRange, valueRange.Parent.UsedRange)
16
17     On Error GoTo 0
18
19     'determine default value
20     Dim defaultString As Variant
21     defaultString = InputBox("Enter the default value", , "#N/A")
22     'strptr is undocumented
23     'detect cancel and exit
24     If StrPtr(defaultString) = 0 Then
25         Exit Sub
26     End If
27
28     Dim dictCategories As New Dictionary
29
30     Dim categoryRange As Range
31     For Each categoryRange In selectedRange
32         'skip the header row
33         If categoryRange.Address <> selectedRange.Cells(1).Address Then
34             dictCategories(categoryRange.Value) = 1
35     Next categoryRange
36
37     valueRange.EntireColumn.Offset(, 1).Resize(, dictCategories.Count).Insert
38     'head the columns with the values

```

```

34
35     Dim valueCollection As Variant
36     Dim counter As Long
37     counter = 1
38     For Each valueCollection In dictCategories
39         valueRange.Cells(1).Offset(, counter) = valueCollection
40         counter = counter + 1
41     Next valueCollection
42
43     'put the formula in for each column
44     '=IF(RC13=R1C,RC16,#N/A)
45     Dim formulaHolder As Variant
46     formulaHolder = "=IF(RC" & selectedRange.Column & " =R" & _
47         valueRange.Cells(1).Row & "C,RC" & valueRange.Column & "," &
48         defaultString & ")"
49
50     Dim formulaRange As Range
51     Set formulaRange = valueRange.Offset(1, 1).Resize(valueRange.Rows.Count -
52         1, dictCategories.Count)
53     formulaRange.FormulaR1C1 = formulaHolder
54     formulaRange.EntireColumn.AutoFit
55
56     Exit Sub
57
58 ErrorNoSelection:
59     'TODO: consider removing this prompt
60     MsgBox "No selection made. Exiting.", , "No selection"
61 End Sub

```

SeriesSplitIntoBins.md

```

1 Public Sub SeriesSplitIntoBins()
2
3     Const LESS_THAN_EQUAL_TO_GENERAL As String = "<= General"
4     Const GREATER_THAN_GENERAL As String = "> General"
5     On Error GoTo ErrorNoSelection
6

```

```

7 Dim selectedRange As Range
8 Set selectedRange = Application.InputBox("Select category range with
   heading", Type:=8)
9 Set selectedRange = Intersect(selectedRange, selectedRange.Parent.
   UsedRange) _
10                               .SpecialCells(xlCellTypeVisible, xlLogical +
   _
11                               xlNumbers + xlTextValues)
12
13 Dim valueRange As Range
14 Set valueRange = Application.InputBox("Select values range with heading",
   Type:=8)
15 Set valueRange = Intersect(valueRange, valueRange.Parent.UsedRange)
16
17 'need to prompt for max/min/bins
18 Dim maximumValue As Double, minimumValue As Double, binValue As Long
19
20 minimumValue = Application.InputBox("Minimum value.", "Min", _
21                                     WorksheetFunction.Min(selectedRange),
22                                     Type:=1)
23
24 maximumValue = Application.InputBox("Maximum value.", "Max", _
25                                     WorksheetFunction.Max(selectedRange),
26                                     Type:=1)
27
28 binValue = Application.InputBox("Number of groups.", "Bins", _
29                                 WorksheetFunction.RoundDown(Math.Sqrt(
30                                 WorksheetFunction.Count(selectedRange)
31                                 ), _
32                                 0), Type:=1)
33
34 On Error GoTo 0
35
36 'determine default value
37 Dim defaultString As Variant
38 defaultString = Application.InputBox("Enter the default value", "Default
   ", "#N/A")
39
40 'detect cancel and exit

```

```

37 If StrPtr(defaultString) = 0 Then Exit Sub
38
39 'TODO prompt for output location
40
41 valueRange.EntireColumn.Offset(, 1).Resize(, binValue + 2).Insert
42 'head the columns with the values
43
44 'TODO add a For loop to go through the bins
45
46 Dim targetBin As Long
47 For targetBin = 0 To binValue
48     valueRange.Cells(1).Offset(, targetBin + 1) = minimumValue + (
49         maximumValue - _
50         minimumValue) *
51         targetBin / binValue
52
53 Next
54
55 'add the last item
56 valueRange.Cells(1).Offset(, binValue + 2).FormulaR1C1 = "=RC[-1]"
57
58 'FIRST =IF($D2 <=V$1,$U2,#N/A)
59 '=IF(RC4 <=R1C,RC21,#N/A)
60
61 'MID =IF(AND($D2 <=W$1, $D2>V$1),$U2,#N/A) '''W current, then left
62 '=IF(AND(RC4 <=R1C, RC4>R1C[-1]),RC21,#N/A)
63
64 'LAST =IF($D2>AA$1,$U2,#N/A)
65 '=IF(RC4>R1C[-1],RC21,#N/A)
66
67 'TODO add number format to display header correctly (helps with charts)
68
69 'put the formula in for each column
70 '=IF(RC13=R1C,RC16,#N/A)
71 Dim formulaHolder As Variant
72 formulaHolder = "=IF(AND(RC" & selectedRange.Column & " <=R" & _
73     valueRange.Cells(1).Row & "C," & "RC" & selectedRange.
74     Column & ">R" & _
75     valueRange.Cells(1).Row & "C[-1]" & ")" & ",RC" &
76     valueRange.Column & "," & _

```

```

72         defaultString & ")"
73
74     Dim firstFormula As Variant
75     firstFormula = "=IF(AND(RC" & selectedRange.Column & " <=R" & _
76         valueRange.Cells(1).Row & "C)" & ",RC" & valueRange.
77         Column & "," & defaultString _
78         & ")"
79
80     Dim lastFormula As Variant
81     lastFormula = "=IF(AND(RC" & selectedRange.Column & " >R" & _
82         valueRange.Cells(1).Row & "C)" & ",RC" & valueRange.
83         Column & "," & defaultString _
84         & ")"
85
86     Dim formulaRange As Range
87     Set formulaRange = valueRange.Offset(1, 1).Resize(valueRange.Rows.Count -
88         1, binValue + 2)
89     formulaRange.FormulaR1C1 = formulaHolder
90
91     'override with first/last
92     formulaRange.Columns(1).FormulaR1C1 = firstFormula
93     formulaRange.Columns(formulaRange.Columns.Count).FormulaR1C1 =
94         lastFormula
95
96     formulaRange.EntireColumn.AutoFit
97
98     'set the number formats
99
100     formulaRange.Offset(-1).Rows(1).Resize(1, binValue + 1).NumberFormat =
101         LESS_THAN_EQUAL_TO_GENERAL
102     formulaRange.Offset(-1).Rows(1).Offset(, binValue + 1).NumberFormat =
103         GREATER_THAN_GENERAL
104
105     Exit Sub
106
107 ErrorNoSelection:
108     'TODO: consider removing this prompt
109     MsgBox "No selection made. Exiting.", , "No selection"

```

105 End Sub

Sheet_DeleteHiddenRows.md

```
1 Public Sub Sheet_DeleteHiddenRows()  
2     'These rows are unrecoverable  
3     Dim shouldDeleteHiddenRows As VbMsgBoxResult  
4     shouldDeleteHiddenRows = MsgBox("This will permanently delete hidden rows  
5         . They cannot be recovered. Are you sure?", vbYesNo)  
6  
7     If Not shouldDeleteHiddenRows = vbYes Then Exit Sub  
8  
9     Application.ScreenUpdating = False  
10  
11     'collect a range to delete at end, using UNION-DELETE  
12     Dim rangeToDelete As Range  
13  
14     Dim counter As Long  
15     counter = 0  
16     With ActiveSheet  
17         Dim rowIndex As Long  
18         For rowIndex = .UsedRange.Rows.Count To 1 Step -1  
19             If .Rows(rowIndex).Hidden Then  
20                 If rangeToDelete Is Nothing Then  
21                     Set rangeToDelete = .Rows(rowIndex)  
22                 Else  
23                     Set rangeToDelete = Union(rangeToDelete, .Rows(rowIndex))  
24                 End If  
25                 counter = counter + 1  
26             End If  
27         Next rowIndex  
28     End With  
29  
30     rangeToDelete.Delete  
31  
32     Application.ScreenUpdating = True  
33     MsgBox (counter & " rows were deleted")
```

34 End Sub

UnhideAllRowsAndColumns.md

```
1 Public Sub UnhideAllRowsAndColumns()  
2  
3     ActiveSheet.Cells.EntireRow.Hidden = False  
4     ActiveSheet.Cells.EntireColumn.Hidden = False  
5  
6 End Sub
```

UpdateScrollbars.md

```
1 Public Sub UpdateScrollbars()  
2  
3     Dim targetRange As Variant  
4     targetRange = ActiveSheet.UsedRange.Address  
5  
6 End Sub
```