Spreadsheets

You will learn about some important features of Excel.

Online MS-Office information source:
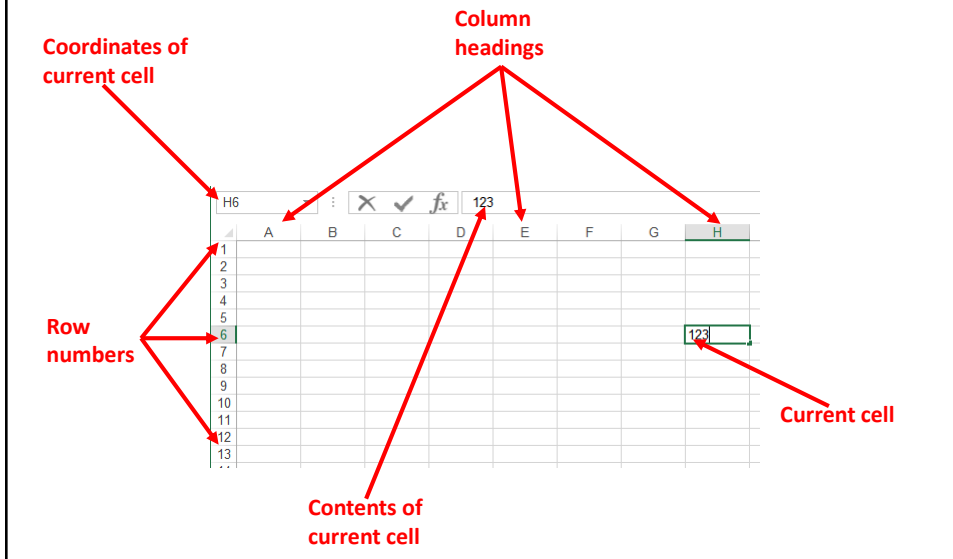https://support.office.com/

Getting Started: **Creating A New Blank SpreadSheet**
(Excel: "Workbook")

- Once Excel has started, select the option for creating a new sheet:
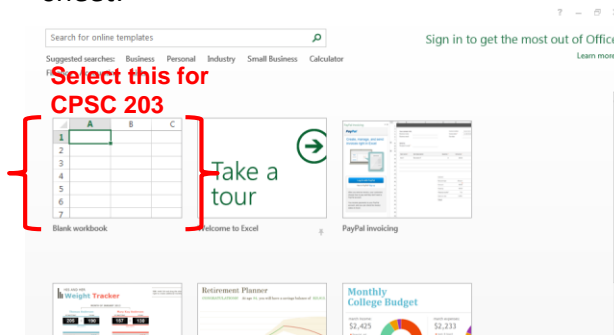
Spreadsheets 101 (Basics)

Coordinates of current cell

Column headings

Row numbers

Current cell

Contents of current cell

Entering Data

- Click on cell to enter the data (in the example: selected cell A1)

	A	B	C
1		Term percent	Letter
2	111	75	B

- Type in cell contents (data entered in the example: 'Student')

	A	B	C
1	Student	Term percent	Letter
2	111	75	B

Contents Of A Cell: Types

- **Raw data**: also referred to as 'constants'

- **Labels**: describe the contents of another cell

- **Formula**: values derived from the raw data (e.g., calculations: =2+2, lookup values: =D2*2, functions: =sum(B2,B9))

Distinguishing Formulas From Text

- In Excel all formulas must be preceded by the '=' symbol ("assignment operator") to distinguish it from text.
- **Example spreadsheet:** 1_formulas
  - Label
    2 + 2

  - **Formula**
    = 2 + 2

    For the sake of brevity, you can assume that all formulas in this section will be preceded by the assignment operator '='

Entering A Formula That Refers To Another Cell Or Cells

- **Approach 1**: type it all in all
  - Click on a cell where you want to enter the formula e.g. click on C2
  - Type in the formula manually e.g. type =A2*B2

	A	B	C
1	Income	Tax rate	Tax owed
2	100000	0.25	=A2*B2

- **Approach 2**: type and click
  - Click on a cell where you want to enter the formula e.g. click on C2
  - When you get to the part of the formula that refers to another cell then just click on the cell (being referred to) rather than typing in the cell address e.g. click on A2 after typing the '=' in C2

1) Click here

2) Reference to Cell A2 appears here

Formatting Cells

- For other information for the other tabs (right clicking on a cell to 'format cells')
  - Similar to the basic features of Word these features will be assumed prior knowledge or knowledge that students can pick up on their own.
  - These features won't be covered in lecture nor will they be covered in tutorial.
  - For more information please refer to the tutorial notes: "excel_basic_features".

Basic Mathematical **Operators**

- **Example spreadsheet:** 2_operators

Mathematical operation	Excel operator	Example
Assignment	=	= 888
Addition	+	= 2 + 2
Subtraction	-	= 7 − 2
Multiplication	*	= 3 * 3
Division	/	= 3 / 4
Exponent	^	= 3 ^ 2

Order Of Operation

Level	Operation	Symbol
1	**B**rackets (inner before outer)	( )
2	**E**xponent	^
3	**D**ivision, **M**ultiplication,	/ *
4	**A**ddition, **S**ubtraction	+ −

- Operations on a higher level are evaluated first

  8 / 2 ^ 3   Equals 8 / 8 or 1

- When a sequence of operators from same level (e.g. addition, subtraction) are encountered in a cell the expression is evaluated from in order in which they appear (left to right).

  2 + 2 - 1   Equals 4 − 1 or 3

Designing Spreadsheets: Rules Of Thumb

1. Do not directly enter values as data that can be derived from other values (this is a numerical calculation example)
   - Example
     - Assignment grade (assume one assignment worth 40%) = 4.2 (data in cell A2)
     - Exam grade (assume only one exam worth 60%) = 3.3 (data in cell B2)
     - Calculate term grade point =(A2*0.4)+(B2*0.6) OR directly enter 3.66?

4.2	3.3		=(A2*0.4)+(B2*0.6)

A2   **B2**

Assignment grade point	Exam grade point	Term grade point
4.2	3.3	3.66

Designing Spreadsheets: Rules Of Thumb (2)

1. Do not directly enter values as data that can be derived from other values (the '&' operator connects text)
   - **Example:** 3_generating_honorifics

=A2 & " " & C2

=A2 & " " & B2

	A	B	C	D
1	Title	First name	Last name	Phone
2	Sifu	James	Tam	(403)210-9455
3	Mr.	Robert	Thurston	(702)333-33333
4	Dr.	Jane	Jones	(614)123-4567
5	Prof.	Allison	Smith	(123)456-7890
6	Ms.	LaRusso	Samatha	(000)000-0000
7				
8				
9				
10	Honorific (Canada)			
11	Sifu Tam			
12	Mr. Thurston			
13	Dr. Jones			
14	Prof. Smith			
15	Ms. Samatha			
16				
17	Honorific (other locations)			
18	Sifu James			
19	Mr. Robert			
20	Dr. Jane			
21	Prof. Allison			
22	Ms. LaRusso			

Manually entered data

Generated (and updated) according to the data

In Excel the ampersand '&' connects text strings

Designing Spreadsheets: Rules Of Thumb (3)

2. **Label information** so it can be clearly understood

Assignment grade point	Exam grade point	Term grade point
4.2	3.3	3.66

Designing Spreadsheets: Rules Of Thumb (4)

3. Never enter the same information more than once

   Example spreadsheet: `4grades_formulas`

   - Advantages: reduces size and complexity of the sheet, making changes can be easier.
   - Seems obvious? Not always
   - Example: What if the previous spreadsheet were used to calculate the grades for a class full of students?
   - Some would create the sheet this way:

Student	Assignment grade point	Exam grade point	Term grade point
1	4.2	3.3	3.66
2	3.3	3.7	3.54
3	2.3	1	1.52
4	4	4	4

=(B2*0.4)+(C2*0.6)

=(B3*0.4)+(C3*0.6)

Etc.

Designing Spreadsheets: Rules Of Thumb (5)

Student	Assignment grade point	Exam grade point	Term grade point
1	4.2	3.3	3.66
2	3.3	3.7	3.54
3	2.3	1	1.52
4	4	4	4

=(B2*0.4)+(C2*0.6)

=(B3*0.4)+(C3*0.6)

Etc.

- Issues:
  - Making changes: What if the value of each component (40% assignments, 60% exams) changed?
    - Retyping/modifying all formulas is inefficient (at least a copy-paste is needed)
  - Clarity: What does the 0.4 & 0.6 refer to (sometimes it's not so obvious)? It violates the "label information" rule of thumb.

Lookup Tables

- **Example spreadsheet**: 5_grades_lookup
- As the name implies it contains information that needs to be referred to ("**looked up**") in a part of the spreadsheet.
- Can be used to address some of the issues related to the previous example:
  - Clarity
  - Entering the same data multiple times

=(B2*$G$2)+(C2*$G$3)

	A	B	C	D	E	F	G
1	Student	Assignment grade point	Exam grade point	Term grade point		Component	Weight
2	1	4.2	3.3	3.66		Assignment	0.4
3	2	3.3	3.7	3.54		Exam	0.6
4	3	2.3	1	1.52			
5	4	4	4	4			
6	AVERAGES	3.45	3	3.18			

Quick Hint #1: When To Use the $ Sign (Absolute Cell Reference)

- If a formula always **refers to the same location** in the spreadsheet (e.g. lookup table or lookup cell)

=(B2*$G$2)+(C2*$G$3)

Changing the lookup table values automatically changes all **cells** that refer to the table (i.e. term GPAs update)

	D	E	F	G
1	Term grade point		Component	Weight
2	3.66		Assignment	0.4
3	3.54		Exam	0.6
4	1.52			

	D	E	F	G
1	Term grade point		Component	Weight
2	3.48		Assignment	0.2
3	3.62		Exam	0.8

- Always precede references to cells being looked up with a dollar sign
  - Values in G2 and G3 are needed in calculations for *all* students so the row and column are preceded by a dollar sign: (B2*$G$2)*(C2*$G$3)
  - The dollar signs ensure that when the formula is copy-pasted, other student's term grade points always refers to grade weightings specified in the lookup table defined in Cell G2 and Cell G3.

Quick Hint #2: When NOT To Use the $ Sign (Relative Cell Reference)

- If a formula will refer to *different* cells if it is copy-pasted (or moved) to another part of the spreadsheet.
  - E.g. assignment and exam GPA used to calculate term grade.

Original formula =(B2*$G$2)+(C2*$G$3)

	A	B	C	D	E	F	G
1	Student	Assignment grade point	Exam grade point	Term grade point		Component	Weight
2	1	4.2	3.3	3.66		Assignment	0.4
3	2	3.3	3.7	3.54		Exam	0.6
4	3	2.3	1	1.52			
5	4	4	4	4			

Formula copied down 1 row (**row +1**) =(B3*$G$2)+(C3*$G$3)

Relative Cell Reference: No $ Sign

	A	B	C	D
1	Student	Assignment grade point	Exam grade point	Term grade point
2	1	4.2	3.3	3.66
3	2	3.3	3.7	3.54

fx =(B2*$G$2)+(C2*$G$3)

- General rule:
  - If the formula is moved/copied '**down**' by 'a' rows then the relative row references **increases** by 'a' amount.
    - Previous example: formula is copied down by 1 row so the cell references increased by 1: from B2 to B3 (+1) for the assignment component and from C2 to C3 (+1) for the exam component.
    - Thus the formula changed:
      - From: =(**B2***$G$2)+(**C2***$G$3)
      - To: =(**B3***$G$2)+(**C3***$G$3)
  - If the formula is moved/copied '**up**' by 'a' rows then the relative row references **decreases** by 'a' amount.
  - If the formula is moved/copied '**left**' by 'c' rows then the relative cell references **decreases** by 'c' amount.
  - If the formula is moved/copied '**right**' by 'd' rows then the relative cell references **increases** by 'd' amount.

Relative Cell Reference: Errors

- If a relative cell reference produces a row or column reference outside the valid range (e.g. below 'A' or '1') an error message will appear.
- Example: copy the relative cell reference from D3 to D1.

D3				fx	=B1
	A	B	C	D	
1	1	2		#REF!	
2	3	4			
3				2	
4					

  - The new formula would refer to Cell =B1 minus two rows (not possible).
- Maximum number of cells in an Excel spreadsheet[1]
  - 1,048,576 rows by 16,384 columns
  - (This information is included for your own reference rather than something you should know as a requirement for the exam).

Cell References: Example Exam Question

- What's the result of copying the expression from F3 to G4?

F3		▼	⋮	✕	✓	f_x	=C3*B3

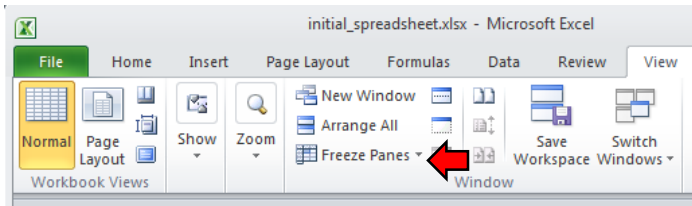| ◢	B	C	D	E	F
1					
2	7	7	7		
3	2	4	6		8
4	1	2	3		

- Note: **References to empty cells** (e.g. B1) that are **used in a mathematical expression return 0**.
  - Example `B1 + C1 = 0`

Data Too Big For Your View

- Covered in this section of lectures notes
  - Freezing panes
  - Simple merging of cells (merging cells on a single row).

- Covered in the introductory tutorial notes
  - Resizing rows or columns
  - Wrap the data
  - Merge data (merging multiple rows as well as multiple columns)

"Freezing" Panes: How/Why

- Often used to lock the view so labels always stay onscreen regardless of which part of the sheet you are viewing.
- Obviously this is useful for cases that contain column (or row) headings.
- Running the Freeze Panes feature: `View -> Window: Freeze Panes`

Freezing Panes: Effect On Example Spreadsheet

Freeze Panes: Procedure

- Move to the row below the row to be 'frozen'.
- In the previous example with student grades it would be Row 3.
- Select:
  - `View -> Window : Freeze Panes` and then select the "Freeze Pane" option among the options.

Merging The Columns Along A Single Row

- Combines the columns into one wider column.
- Before the merge

	A	B	C	D	E
1	CPSC 203: winter 2063				
2	A1 grade	A2 grade	A3 grade	Midterm	Final exam

- (Merging Row 1: Col A – E)
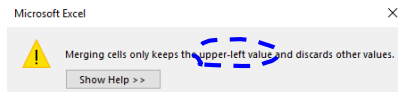- After "`Merge & Center`" (merge and **center align**)

	A	B	C	D	E
1			CPSC 203: winter 2063		
2	A1 grade	A2 grade	A3 grade	Midterm	Final exam

- After the `Merge Across`, `Merge Cells` (merge and retain **previous alignment settings**)

	A	B	C	D	E
1	CPSC 203: winter 2063				
2	A1 grade	A2 grade	A3 grade	Midterm	Final exam

Merge Columns (Each Containing Data)

- Only the **data in the top left-most cell of the merged range is retained**.

  Microsoft Excel   ×

  ⚠ Merging cells only keeps the upper-left value and discards other values.
  Show Help > >

- Before the merge.

	A	B	C
1	CPSC 203: winter 2063		L01

- After the merge: Merge and center ("L01" is lost)

	A	B	C
1		CPSC 203: winter 2063	

- After the merge: Merge across, Merge cells (data "L01" is lost)

	A	B	C
1	CPSC 203: winter 2063		

Copy-Paste: Explanation

- A single cell or a range of cells can be copied (or cut) and pasted.
- There are a number of options for how the originating cell or cell is pasted into the new location.
- We will cover a few of the options for this class
  - "**Paste**": copies the formula (which may be modified if the cell references are relative)
    - May update final values if the data changes (relative references used).
  - "**Paste values**": includes only data or the final result of a formula.
    - If the formula changes then the pasted data won't be updated.
  - "**Paste link**"(always updates to the current value in the source cell)

Copy-Paste: Example

- **Example spreadsheet:** 6_copy_paste
  – Copy paste from A3 into C3 (paste current formula), D3 (paste current data), D3 (paste link)

=$A$5*$B$5   =$A$5*$B$5   56   =$A$3

	A	B	C	D	E
2	Original formula		Paste	Paste values	Paste link
3	56		56	56	56
4					
5	7	8			

  – Changes in **data** in the source cell: if the values in A5 & B5 change to **9** and **6** respectively what will the values be in C3, D3, E3 and why.
  – Changes in the **formula** in the source cell: Contents of A3 was changed to **=9*3**

Copy-Paste

- For your information: Multiple cells (an entire row, column or even a range of cells e.g. A1:C10 can by copied-pasted)

Autofill

- Allows for a sequence (constant or addition by a constant amount) to be extended
  - E.g., The sequence "1, 2, 3" (can be extended to include "…4, 5, 6")
- Steps:
  1. Highlight the cells containing the sequence to extend (selecting one cell just repeats the contents of that one cell).

  2. Move the mouse pointer to the 'handle' at the bottom right

Autofill (2)

  3. Drag the mouse as far down as you wish the sequence to be extended to.

Autofill (3)

- It's best to only extend a sequence that only employs addition (e.g. +1, +3, -1, -10) or a constant sequence using autofill handles.

- To extrapolate other sequences (e.g. multiplication) don't use autofill:
  - https://support.office.com/en-us/article/project-values-in-a-series-5311f5cf-149e-4d06-81dd-5aaad87e5400

Autofill: Practice

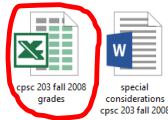- What would be the autofill result of the following.

E.g.1

	A
1	student
2	1
3	10

E.g. 2

	A
1	student
2	1
3	10

Terminology

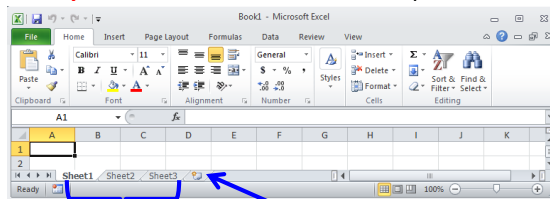- Spreadsheet (referred to as a "workbook" by Microsoft)
  - A Microsoft **Excel file**

- **Worksheet**
  - A part of a spreadsheet

Worksheets

- Each *spreadsheet* can consist of multiple *worksheets*.
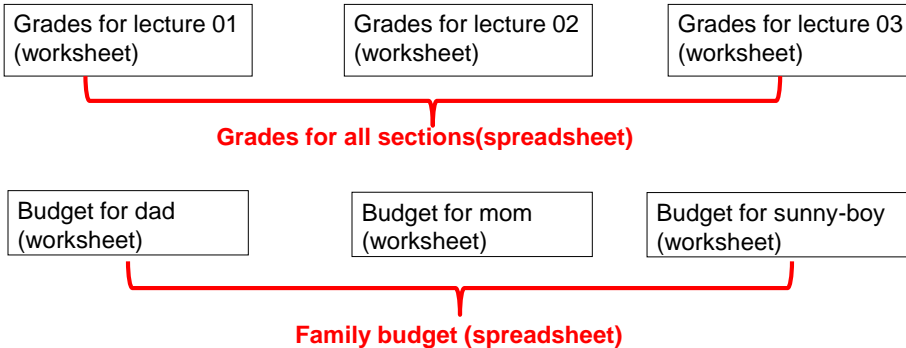

Worksheet   **Create new worksheet**

Spreadsheet

  - Example:
    - Spreadsheet: all my CPSC 203 grades for the **CPSC 203 fall 2008 term**.
    - Worksheets for each of the **two lectures** taught by this instructor that term.
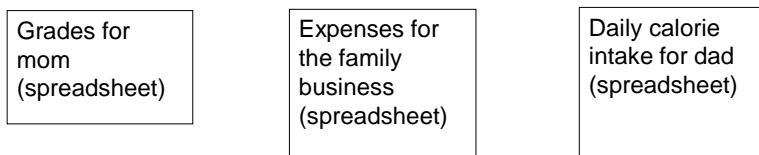
When To Use Multiple Worksheets

- Rules of thumb:
  - When there are multiple sheets of related information, each group of information can be stored in it's own worksheet (self contained)

Grades for lecture 01 (worksheet)	Grades for lecture 02 (worksheet)	Grades for lecture 03 (worksheet)

Grades for all sections(spreadsheet)

Budget for dad (worksheet)	Budget for mom (worksheet)	Budget for sunny-boy (worksheet)

Family budget (spreadsheet)

When Not To Use Multiple Worksheets

- If the information consists of groups of unrelated information then the information about each group should be stored in a separate spreadsheet/workbook rather than implementing it a spreadsheet with multiple worksheets.

Grades for mom (spreadsheet)	Expenses for the family business (spreadsheet)	Daily calorie intake for dad (spreadsheet)

Referring To Other Worksheets

- One worksheet can refer to information stored in another worksheet.
- **Example spreadsheet:**
  – 7_multiple_worksheet_example

$=A2*'AB\ rate'!A2$

	A	B	C
	Gross income	Taxes owed	Net income
	$111.00	$11.10	$99.90

Income tax calculator | AB rate ...

	A	B	C	D
	Tax rate			
	10.00%			

Income tax calculator | **AB rate** .

JT's tip:
- For more complex examples you might want to take extra "in-class" notes.
- (It could be hard to understand the concepts at a level sufficient for the exam or remember notation/symbols if you just look at the slides).

References Between Spreadsheets

- In a fashion similar to using multiple worksheets, one spreadsheet can refer to information stored in another spreadsheet.
- **Example spreadsheets:**
  – 8A_multiple_spreadsheet_example
  – 8B_multiple_spreadsheet_example

8A   **8B**

=A2*'[8B_multiple_spreadsheet_example.xlsx]AB rates'!$A$2

Why Use Cross References?

	A	B
1	Min. percent	Letter
2	0	F
3	50	D
4	65	C
5	75	B
6	85	A
7		

Student grades Cutoffs

- Cross references:
  - a worksheet refers to another worksheet,
  - a spreadsheet refers to another spreadsheet,
- …may be used when:
  - the second worksheet or spreadsheet contains data that needs to be "looked up" (e.g., a lookup table)
- Some examples where cross reference lookups may be needed:
  - Grade cutoffs
  - Tax brackets
 - Product numbers (lookup a product number to get more information about the product)

Data Validation

- Ensures that the data falls within a valid range (e.g. Age must be 0 – 116) or that a specific type of data is entered (e.g. whole number only).
- Invoking:
  - Data->Data Tools: Data Validation
- **Example spreadsheet:** 9_data_validation
  - Name: no restrictions e.g. "James Tam", "James Tam 2", "James Goldstein-Chan" "James.org"
  - Age: number years (whole number) from 1 – 116
  - Income: can include any value from $0.00 - $1,000,000.00 (cents can be entered)
  - Make sure you include good error messages when setting up data validation rules..
    - Tell the user what range of values and/or the type of values that can be entered.
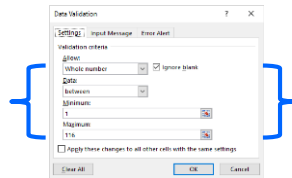

Data Validation Example: Name

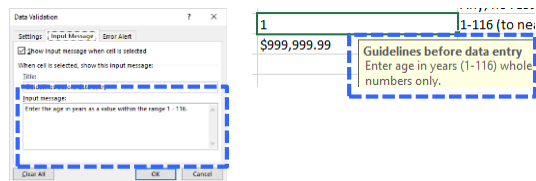- No restrictions on input (this is the default in Excel)
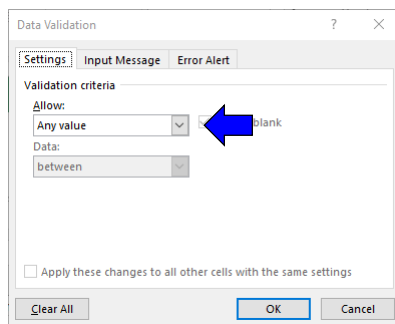
Data Validation Example: Age

- Age must be a whole number from 1 – 116.
- Tools to **prevent errors** in input
  - **Restricting the input**

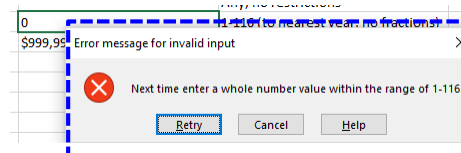

  - **Tooltip** help before data entry

Data Validation Example: Age

- A tool to react **after** bad data has been entered.
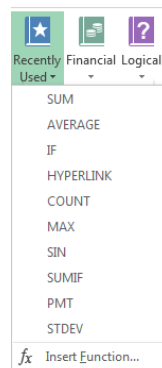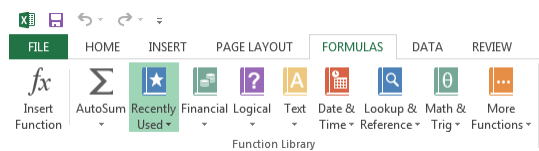 - **Popup error message** appears after the input restrictions have not been met.
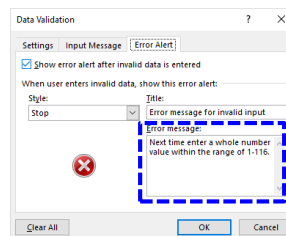
Data Validation Example: Income

- Income allow for any value from $0.00 - $1,000,000.00 (cents may be entered – this is a clue that the input should not be restricted only to whole numbers).

Pre-Created Excel Formulas

What Function Is Right For Your Situation?

- Excel provides reminders.
- Built in functions are grouped into the 'formulas' tab on the ribbon
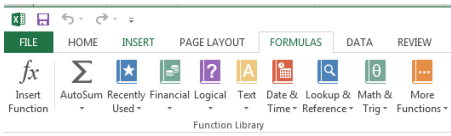
- Also Excel provides "name completion" and "tool tips"

Input Format For Excel Functions

- Required input is typically a **range of cells**
  - **Format**:
    =FUNCTION(*<start cell> : <end cell>*)
  - **Example**:
    =AVERAGE(**A1:A3**)
- Alternatively input may be **fixed inputs** (type data directly into the brackets)
  =AVERAGE(**20,30,10**)

  For the exam you can see either form

- **Optional function inputs ("arguments")**
  Distinguished by the use of square brackets [**optional argument**]
  =IF (*<condition to check>*,
       <return value: condition true>,
       [*<return value: condition false>*])

Basic Statistics

- **Example spreadsheet:**
  - `10_basic_statistics`

- Example formulas: `SUM()`, `AVERAGE()`, `MIN()`, `MAX()`
- General usage:
  - Each formula requires as input a sequence of numbers
  - E.g., formula(1,2,3):
    - Sum = 6   ,   `=SUM(1,2,3)`
    - Average = 2   ,   `=AVERAGE(1,2,3)`
    - Min = 1   ,   `=MIN(1,2,3)`
    - Max = 3   ,   `=MAX(1,2,3)`

Basic Statistics (2)

- Referring to a range of cells

	A	B	C	
1			Sales	
2			**Chinook**	
3	Sales person	Manager	$105,000.00	
4		Assistant	$117,000.00	
5		Employee1	$66,000.00	
6		Employee2	$75,000.00	
7		Employee3	$55,500.00	
8				
9		STORE STATISTICS		
10		Store: total sales	$418,500.00	`=SUM(C3:C7)`
11		Store averages	$83,700.00	`=AVERAGE(C3:C7)`
12		Store: highest	$117,000.00	`=MAX(C3:C7)`
13		Store: lowest	$55,500.00	`=MIN(C3:C7)`

Basic Statistics (3)

- FYI: Ranges can span multiple rows and columns

	A	B	C	D	E	F	G	H
1				Sales At Each Location				
2			Chinook	Market Mall	Sunridge			
3		Manager	$105,000.00	$136,500.00	$100,000.00			
4		Assistant	$117,000.00	$125,000.00	$50,000.00			
5		Employee1	$66,000.00	$64,000.00	$500,000.00			
6		Employee2	$75,000.00	$85,000.00				
7		Employee3	$55,500.00					
8								
9		STORE STATISTICS					OVERALL STATISTICS	
10		Store: total sales	$418,500.00	$410,500.00	$650,000.00		Calgary: total sales	$1,479,000.00
11		Store averages	$83,700.00	$102,625.00	$216,666.67		Calgary: employee average	$123,250.00
12		Store: highest	$117,000.00	$136,500.00	$500,000.00		Calgary: highest employee	$500,000.00
13		Store: lowest	$55,500.00	$64,000.00	$50,000.00		Calgary: lowest employee	$50,000.00

(Column A label, rotated: "Sales person")

`=SUM(C3:E7)`

Counting Functions

- All of these functions tally up the number of cells that do or do not contain a certain type of data e.g., numbers, blank cells...
- General usage:
  FUNCTION(<*start cell range*> : <*end cell range*>)

  – An array (list) of inputs can be the function argument but this is rare except for illustration or examination purposes e.g., =COUNT(1,"A",2)

Counting Functions: COUNT( )

- Counts the number of cells within the specified range that contain a numeric value.
- https://support.office.com/en-US/article/COUNT-function-A59CD7FC-B623-4D93-87A4-D23BF411294C

	Col C
13	0
14	2
15	"A"
16	
COUNT	=COUNT(C13:C16)

Q: What is the result?

Counting Functions: COUNTA( )

- Counts the number of cells within the specified range that *aren't empty*
- https://support.office.com/en-US/article/COUNTA-function-7DC98875-D5C1-46F1-9A82-53F3219E2509

	Col C
13	0
14	2
15	"A"
16	
COUNTA	=COUNTA(C13:C16)

Q: What is the result?

Counting Functions: COUNTBLANK()

- Counts the number of empty cells within the specified range
- https://support.office.com/en-US/article/COUNTBLANK-function-6A92D772-675C-4BEE-B346-24AF6BD3AC22

	Col C
13	0
14	2
15	"A"
16	

COUNTBLANK	=COUNTBLANK(C13:C16)

Counting Functions: Spreadsheet Example

- **Example spreadsheet:** `11_counting_functions`

	B	C	D	E	F
1		Sales At Each Location			
2		Sunridge	Market Mall	Chinook	Future location
3	Manager	$100,000.00	$136,500.00	$105,000.00	
4	Assistant	$50,000.00	$125,000.00	$117,000.00	
5	Employee1	$50,000.00	$64,000.00	$66,000.00	
6	Employee2		$85,000.00	$75,000.00	
7	Employee3			$55,500.00	
8					
9	**Counting functions**				
10	Number employees	3	4	5	0
11	Number unstaffed positions	2	1	0	5
12					
13	Employee slots filled	12	=COUNT(C3:E7)		
14	Employee slots vacant	3	=COUNTBLANK(C3:E7)		

- COUNT(): Also used in Row 10
- COUNTBLANK(): Also used in Row 11

Counting Functions: Spreadsheet Example (2)

– COUNTA( ): Number of cases where the employee name has been entered into the system.
  • That is, blank cells can be either for unstaffed positions or cases where the name of the staff member has not yet been entered.

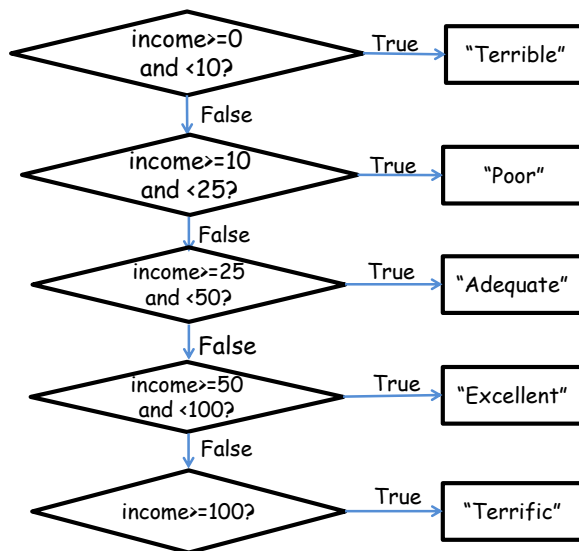|	A	B	C	D	E
1		Sales At Each Location			
2		Sunridge	Market Mall	Chinook	Future location
3	Manager	Ron Ridge	Dean Perkins	Don Torrie	
4	Assistant		James Tam	2cool Person	
5	Employee1		Dave Meek		
6	Employee2				
7	Employee3				
8					
9	**Counting functions**				
10	Current staffing	1	3	2	0
11	Vacancies	4	2	3	5

=COUNTA(B3:B7)

Lookup Functions

• One common use of a lookup function is to determine which category that some numeric value resides.
• Membership in a category is often determined by ranges:
  – Mapping raw scores to a letter grade.
  – Determining your 'tax bracket'.
  – Evaluating your "FICO" credit score.

Lookup Tables

- Lookup functions require a 'lookup table' that specifies the ranges.
  - Example: for your given grade in a course, a lookup table specifies the various cutoffs for the different letter grades.
  - Similar to a lookup table containing constants but these examples are for a range of values (there are strict requirements in the format) rather than a single value.
- **Important format requirements** for the **first column** of the lookup table examples covered this term:
  - table values must be in **ascending order**,
  - column values can only be **numeric**.
- In the example the data in cells **D11 – D15** follow these requirements.

	D	E
10	Min income	Comment
11	0	Terrible
12	10	Poor
13	25	Adequate
14	50	Excellent
15	100	Terrific

Example: Specifying Conditions

income>=0 and <10? →True→ "Terrible"

↓False

income>=10 and <25? →True→ "Poor"

↓False

income>=25 and <50? →True→ "Adequate"

↓False

income>=50 and <100? →True→ "Excellent"

↓False

income>=100? →True→ "Terrific"

Min income	Comment
0	Terrible
10	Poor
25	Adequate
50	Excellent
100	Terrific

According to the values in this table: a numeric value<0 is an error condition

VLOOKUP

- Official link for help
  - https://support.office.com/en-US/article/VLOOKUP-function-0BBC8083-26FE-4963-8AB8-93A18AD188A1
- **Format**:

  VLOOKUP(<***Lookup value***>,

  <***Lookup table   Start : End***>,

  <***Lookup table Column specifying the return value***>)

- **Example**:

  =VLOOKUP(**B2**,   D11:E15,   **2**)

  Cell:
  Contains value to find in table e.g., a grade point

  Lookup table:
  Start : End
  cell coordinates

  Lookup table:
  Column value to return, fo
  this example:
  (1 = first col. = 'D',
  2 = second col. = 'E')

VLOOKUP: Investments

- **Example spreadsheet:** 12_vlookup

=VLOOKUP(B2,D11:E15,2)

	A	B	C
1	Stock	Net income (millions of $)	Invest?
2	PEAR	$1,000.00	Terrific
3	TAM	$50.00	Excellent
4	SCAM	$1.00	Terrible

	Col D (1st) Min income	Col E (2nd) Comment
11	0	Terrible
12	10	Poor
13	25	Adequate
14	50	Excellent
15	100	Terrific

VLOOKUP: **Multi-Column** (3+) Lookup Table

- **Name of example spreadsheet**:
  13_vlookup_multiple_columns

Lookup function

Lookup table

Conditional Counting Function

- Increases a tally count if one or conditions have been met
- COUNTIF()

Conditional Counting Function: COUNTIF()

- Counts the number of cells that meets a particular requirement
  - How many employees of a multi-national corporation are Canadian?
  - How many students in a class were awarded an "A+" grade?
  - Example below: Count the number of cells within the range that contain a positive numeric value.

	A
1	0
2	2
3	A
4	=COUNTIF(A1:A3,">0")

  - https://support.office.com/en-US/article/COUNTIF-function-E0DE10C6-F885-4E71-ABB4-1F464816DF34

Conditional Counting Function: COUNTIF(), 2

	A
1	0
2	2
3	A
4	=COUNTIF(A1:A3,"B")

COUNTIF(): Full Example

- **Example spreadsheet:** 14_countif
- Conditions tallied
  - Which employees met quota? (If the cell contains "Yes")
  - Which employees had sales that were deemed as high (above $100,000)

	A	B	C
1	Employee	2017 sales quota met?	2017 sales in $
2	James	Yes	$100,000
3	Dave	Yes	$123,456
4	Ernie		$55,000
5	Ron		$66,000
6	Don	Yes	$118,000
7	Lucie		$75,000

`=COUNTIF(B2:B7,"YES")`

	A	B
9	# Met quota	3
10	High sales	2

`=COUNTIF(C3:C8,">100000")`

Recall: From Word Mail Merge Filters

- Example Mail merge filters covered previously
  - Filter rule based on age:
    - 65 and over: "You get a seniors discount."
    - Under 65: "No seniors discount."
- The If-Then-Else filter checks if a condition has been met e.g. a field in the spreadsheet data source was equal to some value.
  - If the condition has been met (**condition = true**) then display a message.
  - If the condition has not been met (**condition = false**) then display another message.

Insert Word Field: IF

IF

Field name: Age
Comparison: Greater than or equal
Compare to: 65

Insert this text:
You get a seniors discount.

Otherwise insert this text:
No seniors discount.

New Terminology

- **A Boolean expression** takes a condition (a comparison such as degree being equal to 'B.Sc.'') as input and returns a Boolean value.
  - The conditions must be specified to yield either a Boolean result.
- **Boolean / Boolean value**: must be either true or false

Insert Word Field: IF		?	×
IF			
Field name:	Comparison:	Compare to:	
Age	Greater than or equal	65	

The result of this comparison is Boolean (the condition can only be met or not met).

  - Examples of statements that must be true or false:
    - A job applicant has been awarded a B.A. degree.
    - The customer is a senior citizen.
    - It is below freezing [freezing point of water] today.

Format: IF-ELSE

- **Format**:

  =if (<*Boolean expression*>,

      <*Boolean return value: condition true*>,

      [<*Boolean return value: condition false*>])

  - Reminder: square brackets [] is the notation used by Microsoft for optional arguments

- **Example**:

  =IF (**B2>=100**,**"GO!"**,**"Don't' waste your $"**)

- Official help link
  - https://support.office.com/en-US/article/IF-function-69aed7c9-4e8a-4755-a9bc-aa8bbff73be2?CorrelationId=6aeb3056-a94b-47ac-af6e-90dff250a029

Excel IF-Function: Investing Example

- In column 'C' the sheet will display "GO!" if net income is 100 (millions of $) or greater "Don't waste your $" otherwise.
  - **Example spreadsheet:** 15_if_invest_or_not

Boolean expression

```
=IF    (B2>=100, "GO!", "Don't' waste your $")
```

Return: condition true   **Return: condition false - "else case"**

⊿	A	B	C
1	Stock	Net income (millions of $)	Invest?
2	PEAR	$1,000.00	GO!
3	TAM	$888.00	GO!
4	POOR	$1.00	Don't waste your $
5	Average	$629.67	GO!

Comparators

Mathematical representation	Excel representation	Meaning
<	<	Less than
>	>	Greater than
=	=	Equal to
≤	<=	Less than, equal to
≥	>=	Greater than, equal to
≠	<>	Not equal to

Example **Return Values**

Type of return value	Example return value	Example use
Text	*"GO"*	=IF (B2>=100,"GO!", "No go")
Numeric	4, 4.0	=IF (C3="A+",4.3, -1)
Cell reference	A2, A3	=IF(A1>0,A2,A3)
Boolean	True, False	=IF(1>2,True,False)

IF: Specifying Only The True Case (Poor Approach)

- **Example spreadsheet:**
  16_if_else_invest_or_not_NO_FALSE_return
- If only a return value for the true case has been specified:
  - When the condition has not been met (False result from the Boolean expression)...literally the text "FALSE" will be displayed.

`=IF(B4>=100,"GO!")`

	A	B	C
1	Stock	Net income (millions of $)	Invest?
2	PEAR	$1,000.00	GO!
3	TAM	$888.00	GO!
4	POOR	$1.00	FALSE
5	Average	$629.67	

IF: Specifying Only The True Case (**Better Approach**)

- **Example spreadsheet:** 17_if_else_invest_or_not_ammended
- Consequently:
  - When a message is desired only when the 'if condition case' is true then something, even an **empty message**, should be specified for the 'else return case' (false that the condition has been met).

⊿	A	B	C
1	Stock	Net income (millions of $)	Invest?
2	PEAR	$1,000.00	GO!
3	TAM	$888.00	GO!
4	POOR	$1.00	
5	Average	$629.67	

`=IF(B4>=100,"GO!","")`

Logic: What You Learned

- You were informally taught the **AND** as well as the **OR** logical operations in the section covering Internet searches.
- Example:
  - "James Tam" Calgary   Logical **AND** (default)
  - Vs.
  - "James Tam" **OR** Calgary   Logical **OR**
- More formally: AND, OR are logical operators
- Mathematical operators take numbers as input and return a number
- **New term: Logical operators** take a Boolean as input and return a Boolean value.
  - Logical operators can connect compound (2+) Boolean expressions.
  - (Boolean expression) Logical operator (Boolean expression) etc.

Logical AND: All Restrictions

- Used when **all conditions** / Boolean expressions (BE) must be true
- Example:
  - Prerequisites for CPSC 233: Introductory programming course as well as discrete math ("as well as" = AND in this case).
  - `Intro programming grade >= C-  AND  Math grade >= C-`

    Condition 1 / BE 1   **Condition II / BE 2**

  - If either course grade is not satisfactory it's false that the requirement is met.
    - With Logical-**AND** if *any* **Boolean Expression is false** then the **entire compound condition is made false**.
  - Only if all course grades satisfactory will it be true that the pre-requisites have been met.
    - With Logical-**AND** only if *all* **conditions are true** will the entire **compound condition be true.**

Logical AND: Many Conditions

- To evaluate the result just extend the general rule:
  - Multiple AND-expressions **must all be true** for the overall **result** to be **true**.
  - If **at least one** expression is **false** then the overall **result** is **false**.
- Example:
  - Internet search: **"James Tam" CPSC Calgary**
    - Before a webpage appears as a search result, all three conditions must be met (the three text phrases must appear in that page).
      - The more search phrases that you include, the more narrow will be your results (fewer).
  - A course with 3 or more prerequisites.
  - Job applicants must meet 3 or more requirements e.g. Applicant must be an adult, awarded a university undergraduate degree (or a superior degree), overall grade point from that degree must be at least 3.0.

Logical OR: At least One Restriction

- Used when **at least one** condition / Boolean expression (BE) must be met (true).
- Example:
  - Prerequisites for CPSC 233: One of CPSC 217 or 231
  - CPSC 231 GPA >= C- OR CPSC 217 GPA >= A-

      Condition 1   **Condition 2 /**
      / BE 1   **BE 2**

  - If at least one of: CPSC 217, 231 was completed satisfactorily, then the intro programming requirement was met.
    - With Logical-OR if *any* condition / Boolean Expression is true then the **entire compound condition is made true**.
  - Only if no courses were completed satisfactorily then the programming requirement has not been met.
    - With Logical-OR only if *all* conditions are false will the **entire compound condition be false**.

Logical OR: Many Conditions

- As was the case with Logical-AND to evaluate the result just extend the general rule:
  - If **at least one** expression is true then the overall **result** is **true**.
  - Multiple OR-expressions **must all be false** for the overall **result** to be **false**.
- Example:
  - Internet search: "Wayne Gretzky" **OR** "The Great One" **OR** "Number 99" **OR** "Number ninety nine"
    - A website that includes at least one of the text phrases will be shown as a search result.
      - Increasing the number of OR-expressions will broaden (increase) the number of search results.
  - A course with a choice of prerequisites.
  - Job applicants can be awarded one of a number of degrees e.g. B.A., B.Comm, B.Sc. etc.

Mixed Logical Expressions

- AND, OR conditions can be combined in actual usage.
- Example:
  - Internet search: "Wayne Gretzky" **OR** "The Great One" **OR** "Number 99" **OR** "Number ninety nine" **AND** "Edmonton Oilers"
    - A website will show as a search result if it contains at least one of the three 'names' as well as containing the text "Edmonton Oilers".
  - Course prerequisites: CPSC 233 requires one of: CPSC 217, 231 as well as Math 271
    - In actual usage logical operators may be implicit so you should be able to interpret plain English descriptions in an assignment or during an examination.
    - CPSC 217 OR CPSC 231 AND MATH 271
    - With logic and software 'AND' is a higher order precedence than OR so the above is not evaluated left-right, the above is the same as:
      - CPSC 217 OR (CPSC 231 AND MATH 271)
    - (CPSC 217 OR CPSC 231) AND MATH 271   (To avoid confusion bracket expressions to make things explicit).

Logical Functions In Excel

- The basic logical operations: AND, OR can be invoked as functions in Excel
  - Similar to evaluating logical expressions on paper, all Excel logical function inputs can only be a True or False value.
  - Function inputs can be:
    - Boolean **constant** e.g. AND(**True,False,False**)
    - Boolean **expression** e.g. OR(**A1>0,A2>0,3>2**)
    - A **cell** that contains a Boolean value e.g. AND(**A1,A2**), OR(**B1,Z2**)
- **Format**:
  ```
  AND(<True or False>,<True or False>...)
  OR(<True or False>,<True or False>...)
  ```

## Types Of Inputs: Logic Functions

- **Examples** (spreadsheet name: 18_logic)
  ```
  AND(C1>=45,D1="John Smith")
  OR(C1>=0,D2>=0)
  ```

New Terminology: **Nested Calculation**

- Nested calculation: one calculation is nested within another second calculation when the **result of the first calculation is used to determine the result of the second calculation**.
- Simple example:
  - *Calories expended = (**height + 7**) * 100*
- More complex example:
  - First calculation: determine the total cost of salaries and other expenditures for each Canadian province.
  - Second calculation: determine total for all sources of revenue for each province.
  - Third calculation: calculate the surplus (of deficit) for each province
  - = (**sum all provincial revenues**) − (**total provincial expenditures**)
  - The calculations for revenues and expenditures are nested within (part of) the calculation for the surplus (or deficit)

Nested Functions

- The return **result of one function is used as an argument for another function**.

- Example:
  - Find the maximum grade for each lecture section.
  - Example:
    - Lecture 01: =MAX(A2:A101)
    - Lecture 02: =MAX(B2:B101)
  - Calculate the average of the lecture maximums
    - Average of the maximum scores: = AVERAGE(**MAX(A2:A101)**, **MAX(B2:B101)**)

          =MAX(A2:A101)   **MAX(B2:B101)**

              =AVERAGE(,   )
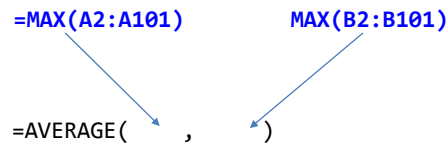
Using One Function's Return Value As Input For Another Function (Nesting Functions: Logic, IF)

- Breaking down the process into parts
  1. **Call a function** and that function **returns** a value e.g. B4 = 3.7, C4 = 4

                          AND(B4>=3.7,C4>=5)

                              Returns **False**

  2. Use the return value of the first function as part/all of the **input** of a second function
     - The first function is *nested* within the second function.

                          =IF(, "H","")
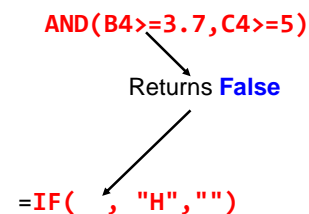
     Actual formulation of the function
     IF(AND(B4>=3.7,C4>=5), "H","")

Logic And IF's: Example

- Being on the Dean's list requires: a grade point of 3.7 or higher and a full load 5 or more courses.
- AND Excel example: Dean's list
  - Signify when a student has made the Dean's list requirements with an "D", blank cell otherwise.

`=IF(AND(B4>=3.7,C4>=5),"D","")`

	A	B	C	D
2	Student	Overall GPA	Number courses	Dean's list
3	1	4	1	
4	2	3.9	5	D
5	3	2.3	5	
6	4	3.7	5	D

- **Example spreadsheet:** `19_if_with_logic`

Logic And IF's: Example (2)

- OR Example: Hired if at least one requirement has been met:
  - work experience of 5+ years,
  - grade 3.7 or higher
  - (Same spreadsheet as previous example)

E12

Total work experience
7

`=IF(OR(E12>=5,G16>=3.7),"1+ requirement met","")`

G16

Overall GPA
3.6

Conditional Formatting

- **Example spreadsheet:** `21_conditional_formatting`
- It can be used to visually highlight data which has met a certain condition.

	A	B
1	**Employee**	**2017 sales in $**
2	James	$100,000
3	Dave	$123,456
4	Ernie	$55,000
5	Ron	$66,000
6	Don	$118,000
7	Lucie	$75,000

Setting Conditional Formatting

- Home Tab-> (Styles group: Conditional formatting)
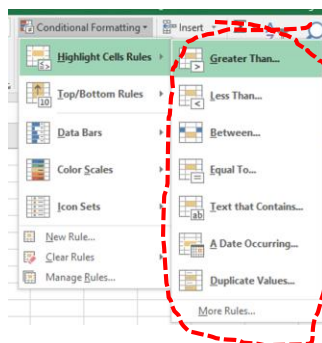
If you don't know much about visual design then keep it simple, stick to the basics!

- With the previous example select:
  - "Greater Than"
  - Enter 99999.99 with "Light Red Fill with Dark Red Text"

Ways Of Graphically Representing Information

- Pie chart

- Bar graph
  - Excel: Column (vertical), bar (horizontal)
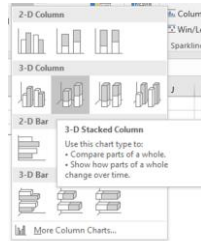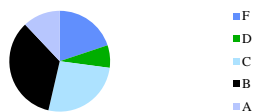
- Line graph

Pie Charts

- Good for showing proportions, how much of the whole does each item contribute.
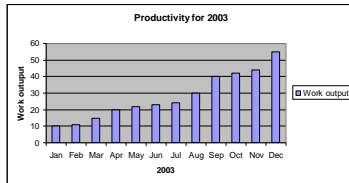
Grade distribution

- F
- D
- C
- B
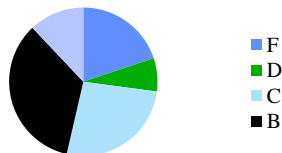
- It's poor for showing exact numeric values.

# of students receiving each grade
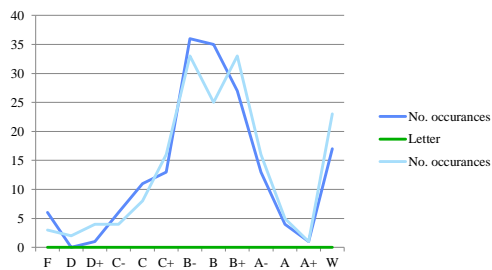
- F
- D
- C
- B
- A

Bar And Line Graphs

- For showing trends

- Comparing functions
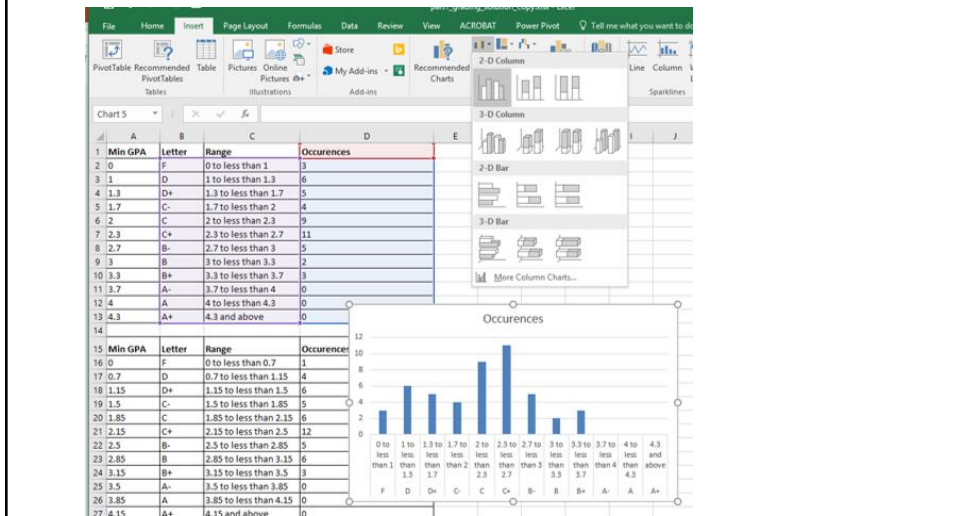

Creating Graphs Using Excel: Specifying Data

- Select the range of cells

| Letter	Range	Occurences
F	0 to less than 1	3
D	1 to less than 1.3	6
D+	1.3 to less than 1.7	5
C-	1.7 to less than 2	4
C	2 to less than 2.3	9
C+	2.3 to less than 2.7	11
B-	2.7 to less than 3	5
B	3 to less than 3.3	2
B+	3.3 to less than 3.7	3
A-	3.7 to less than 4	0
A	4 to less than 4.3	0
A+	4.3 and above	0

Creating Graphs Using Excel: Inserting Graph

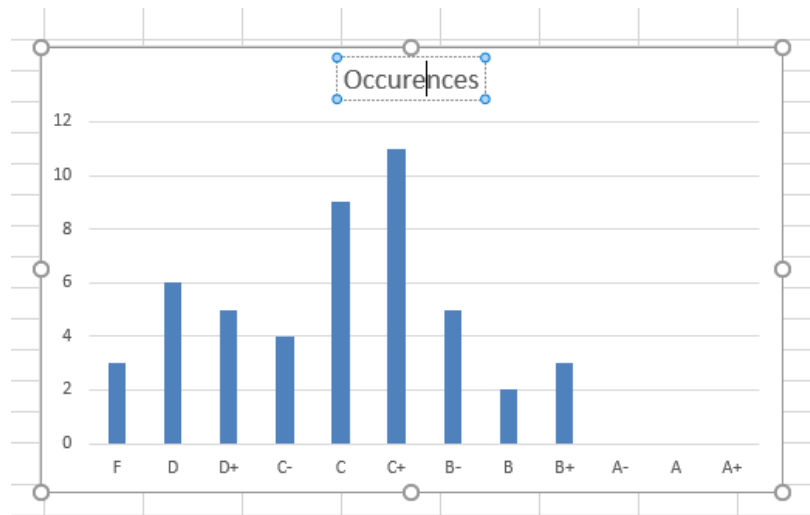- Insert-> (Charts Group: Type of graph e.g. 2D Column)

Creating Graphs Using Excel: Choosing Specific Data

- To select non-adjacent columns select the first column, press and don't release control and then select the next column.
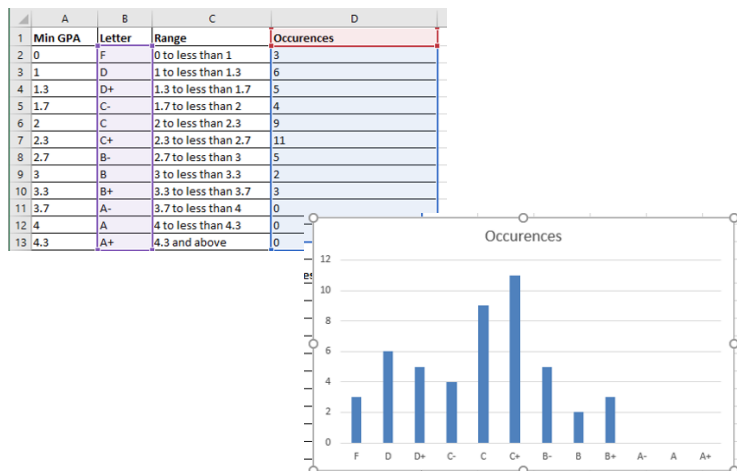
Editing The Graph Title (And Other Parts)

Rules Of Thumb For Graphs

1. What type of graph to use:
   a) Bar graphs are used to plot non-continuous data e.g., the number of patients that go to different hospitals.
   b) Line graphs are used to plot continuous data e.g., mortality trends over time.
2. JT: Avoid or minimize the use 3D graphics! Keep things simple.

After This Section You Should Now Know

- The benefit of electronic over paper spreadsheets
- Spreadsheets 101: The basic layout and components of a spreadsheet
- Entering data: manually and via autofill
- Raw data vs. labels vs. formulas
  - How formulas are distinguished from text
  - Entering formulas that refer to other cells
- Common mathematical operators and the order of operation
- The three rules of thumb for designing spreadsheets
  1. Don't make something data if it can be derived
  2. Label everything so it can be understood
  3. Don't duplicate data

After This Section You Should Now Know (2)

- Lookup tables
  - How to create and use a lookup table
  - Includes lookup tables with constant values and lookup tables to be used in conjunction with lookup function
- When to use absolute vs. relative cell references in formulas
  - How do formulas using absolute vs. cell references change when copied elsewhere
- Ways of changing views when the data is too large for the display
  - Freezing panes
  - Merging cells

After This Section You Should Now Know (3)

- Different forms of copy paste:
  - Paste
  - Paste values
  - Paste link
- What is a worksheet
  - When to use multiple spreadsheets vs. multiple worksheets
  - How to reference data in other spreadsheets or worksheets (cross references)
- How to prevent errors using data validation

After This Section You Should Now Know (4)

- How to use basic statistical formulas: `sum()`, `average()`, `min()`, `max()`
- How to use counting functions: `count()`, `counta()`, `countblank()`, `countif()`
- A lookup function: `vlookup()`
- A conditional counting function: `countif()`
- The 'if-else' function
- Logic functions: `and`, `or`
- Using the output of one function become the input of another function, example: `and`, `or` in conjunction with `if-else`
- How to use basic statistical formulas: `SUM()`, `AVERAGE()`, `MIN()`, `MAX()`

After This Section You Should Now Know (5)

- How to use counting functions: COUNT( ), COUNTA( ), COUNTBLANK( )
- A lookup function: VLOOKUP( )
- A conditional counting function: COUNTIF( )
- The 'IF-ELSE' function
- Logic functions: AND, OR
- Using the output of one function become the input of another function, example: and, or in conjunction with IF-ELSE
- How to apply conditional formatting to a spreadsheet
- When to use pie charts vs. bar graphs vs. line graphs
- How to use graphs in Excel

Images

- "Unless otherwise indicated, all images were produced by James Tam

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