

Formulas, Cell References & Aggregate Functions

Write formulas with confidence. Understand operators and their order, relative, absolute and mixed references, and every aggregate function you need, from SUM and COUNTA to SMALL, LARGE, SUMIFS, COUNTIFS, MAXIFS, SUBTOTAL and AGGREGATE.

● Live class 3

✦ Excel for Microsoft 365, 2026

Beginner

🕒 110 min

By the end of this lesson you can

- Explain the difference between a formula and a function and read any function's syntax
- Predict how a formula changes when copied, and lock references with \$ (F4)
- Summarise data with SUM, COUNT, COUNTA, COUNTBLANK, AVERAGE, MIN, MAX, SMALL, LARGE, MEDIAN and MODE
- Answer conditional questions with COUNTIF(S), SUMIF(S), AVERAGEIF(S), MAXIFS and MINIFS
- Use SUBTOTAL and AGGREGATE for filtered data and data with errors

Datasets used

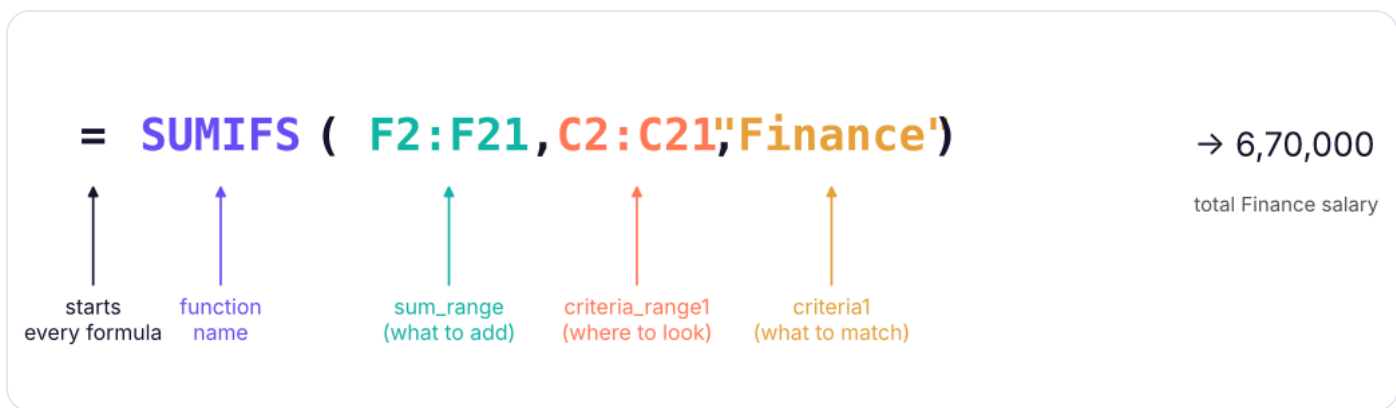
employees_small.csv

superstore_sales.csv

Formula vs function

DEFINITION Two words people mix up

A **formula** is any calculation that starts with `=`. It can use cell references, numbers, operators and functions: `=B2*C2`, `=(B2-C2)/C2`, `=SUM(B2:B10)*1.18`. A **function** is a named, ready-made calculation inside a formula: `SUM`, `AVERAGE`, `IF`. A function has a name, brackets and **arguments** separated by commas.



Anatomy of a function call. Arguments in square brackets are optional.

When you type a function name and `(`, Excel shows a tooltip with its syntax, for example `SUMIFS(sum_range, criteria_range1, criteria1, [criteria_range2, criteria2], ...)`. Press **Ctrl + A** after the bracket to open the **Function Arguments** dialog, which explains every argument and previews the result.

Operators and order of calculation

Operator	Meaning	Example	Result
<code>+ - * /</code>	Add, subtract, multiply, divide	<code>=10+4*2</code>	18
<code>^</code>	Power	<code>=2^10</code>	1024
<code>%</code>	Percent	<code>=500*18%</code>	90
<code>&</code>	Join text	<code>="Q"&2</code>	Q2
<code>= <> > < ≥ ≤</code>	Comparison, returns TRUE/FALSE	<code>=B2 ≥ 100</code>	TRUE or FALSE
<code>:</code>	Range	<code>A1:A10</code>	10 cells
<code>,</code>	Union (inside functions)	<code>=SUM(A1:A3, C1:C3)</code>	Adds both ranges

Excel follows the usual maths order, remembered as **BODMAS/PEMDAS**: brackets, then `^`, then `*` and `/`, then `+` and `-`, then `&`, then comparisons.

X Order of operations			
	A	B	C
1	Formula	Result	Why
2	<code>=10+4*2</code>	18	Multiply first: 10 + 8
3	<code>=(10+4)*2</code>	28	Brackets first: 14 × 2
4	<code>=2^3^2</code>	64	Excel works left to right: (2^3)^2 = 64
5	<code>=-2^2</code>	4	Negation before power in Excel: (-2)^2 = 4
6	<code>=100*(1+18%)</code>	118	Add 18% GST

B2 =10+4*2
B3 =(10+4)*2
B4 =2^3^2
B5 =-2^2
B6 =100*(1+18%)

WATCH OUT ``-2^2`` is 4 in Excel

In maths -2^2 is -4 , but Excel applies the minus sign first. Write `=-(2^2)` if you mean -4 . This catches people in finance formulas.

Cell references: relative, absolute and mixed

When you copy a formula, Excel adjusts its references **relative** to where you paste it. Usually that is exactly what you want. Sometimes a reference must stay fixed, for example a tax rate in one cell. A \$ sign locks the part after it.

Reference	Copy down	Copy right	Name
B2	B3, B4 ...	C2, D2 ...	Relative
\$B\$2	stays \$B\$2	stays \$B\$2	Absolute
B\$2	stays row 2	C\$2, D\$2 ...	Mixed (row locked)
\$B2	B3, B4 ...	stays column B	Mixed (column locked)

Press **F4** while the cursor is on a reference to cycle `B2` → `$B$2` → `B$2` → `$B2` → `B2`.

Absolute reference: one rate for every row

X GST rate in one input cell (G2) — formula in D2 is `=B2*C2*$G$2`, copied down

	A	B	C	D	E	F	G
1	Item	Qty	Price	GST amount	Total		GST rate
2	Notebook	10	45	81.00	531.00		18%
3	Pen pack	25	60	270.00	1,770.00		
4	Stapler	4	180	129.60	849.60		

D2 =B2*C2*\$G\$2
E2 =B2*C2+D2
D3 =B3*C3*\$G\$2
E3 =B3*C3+D3
D4 =B4*C4*\$G\$2

E4 =B4*C4+D4

The GST rate lives in one input cell (yellow). Because \$G\$2 is absolute, every copied formula still points to it. Change the rate once and every total updates.

Mixed references: the multiplication table test

A classic interview question: write **one** formula in B2 that can be copied across and down to fill a multiplication table.

X One formula, =\$A2*B\$1, filled across and down

	A	B	C	D	E	F
1	×	1	2	3	4	5
2	1	1	2	3	4	5
3	2	2	4	6	8	10
4	3	3	6	9	12	15
5	4	4	8	12	16	20
6	5	5	10	15	20	25

B2 =\$A2*B\$1

C2 =\$A2*C\$1

D2 =\$A2*D\$1

E2 =\$A2*E\$1

F2 =\$A2*F\$1

Each pattern is copied down/across to the other cells in its column.

\$A2 always uses column A (the row header) and B\$1 always uses row 1 (the column header). The same idea is used for price × discount grids, sales × commission tables, and loan EMI tables.

X The same table in formula view

Formula view (Ctrl + `)

	A	B	C	D
1	×	1	2	3
2	1	=\$A2*B\$1	=\$A2*C\$1	=\$A2*D\$1
3	2	=\$A3*B\$1	=\$A3*C\$1	=\$A3*D\$1
4	3	=\$A4*B\$1	=\$A4*C\$1	=\$A4*D\$1

References to other sheets and workbooks

Reference	Meaning
=Sales!B2	Cell B2 on the sheet named Sales
= 'Sales 2026' !B2	Quotes are needed when the sheet name has spaces
=SUM(Jan:Mar!B2)	A 3D reference : B2 on every sheet from Jan to Mar
=[Budget.xlsx]Plan!C5	Another workbook (an external link; Data → Edit Links manages them)

Aggregate functions

Aggregate functions turn many values into one number. The examples below use the 20-row employee table stored on a sheet named Emp (columns: A emp_id, B name, C department, D city, E join_date, F salary, G rating).

X Aggregate functions on Emp (salary in F2:F21, rating in G2:G21)			
	A	B	C
1	Question	Formula	Result
2	Total salary	=SUM(Emp!F2:F21)	1,978,000
3	How many numbers in salary	=COUNT(Emp!F2:F21)	20
4	How many non-empty names	=COUNTA(Emp!B2:B21)	20
5	Empty cells in B2:B25	=COUNTBLANK(Emp!B2:B25)	4
6	Average salary	=AVERAGE(Emp!F2:F21)	98,900
7	Median salary	=MEDIAN(Emp!F2:F21)	97,000
8	Most common rating	=MODE.SNGL(Emp!G2:G21)	4
9	Lowest / highest salary	=MIN(...) / =MAX(...)	45,000 / 157,000
10	2nd highest salary	=LARGE(Emp!F2:F21,2)	157,000
11	3rd lowest salary	=SMALL(Emp!F2:F21,3)	57,000
12	Average rating (rounded)	=ROUND(AVERAGE(Emp!G2:G21),2)	3.55

C2 =SUM(Emp!F2:F21)
C3 =COUNT(Emp!F2:F21)
C4 =COUNTA(Emp!B2:B21)
C5 =COUNTBLANK(Emp!B2:B25)
C6 =AVERAGE(Emp!F2:F21)
C7 =MEDIAN(Emp!F2:F21)
C8 =MODE.SNGL(Emp!G2:G21)
C9 =TEXT(MIN(Emp!F2:F21),"#,##0")&" / "&TEXT(MAX(Emp!F2:F21),"#,##0")
C10 =LARGE(Emp!F2:F21,2)
C11 =SMALL(Emp!F2:F21,3)
C12 =ROUND(AVERAGE(Emp!G2:G21),2)

Function	Counts or uses	Ignores
COUNT	Numbers (and dates)	Text, blanks, logical values typed in cells
COUNTA	Anything not empty (numbers, text, errors, "" from formulas)	Truly empty cells
COUNTBLANK	Empty cells and cells with ""	Everything else
SUM, AVERAGE, MIN, MAX	Numbers	Text and blanks in ranges
MEDIAN	Middle value of sorted numbers	Text and blanks
MODE.SNGL	Most frequent number	Text
SMALL(range, k), LARGE(range, k)	k-th smallest or largest	Text and blanks

TIP AVERAGE ignores blanks but not zeros

A blank cell is left out of the average; a zero is counted. If "no data" is stored as 0, your average will be too low. Leave missing values blank, or use AVERAGEIF(range, ">0").

2026 UPDATE MEDIAN vs AVERAGE in salary data

Salaries are usually skewed by a few high earners, so the **median** describes a "typical" employee better than the average. You will meet this again in Statistics (ML track, Lesson 1).

Conditional aggregation: the IFS family

These are the most used analysis functions in Excel. They answer questions such as *"total sales in the North region for Technology in 2025"*.

Function	Syntax
COUNTIF	COUNTIF(range, criteria)
COUNTIFS	COUNTIFS(range1, criteria1, range2, criteria2, ...)
SUMIF	SUMIF(range, criteria, [sum_range])
SUMIFS	SUMIFS(sum_range, range1, criteria1, range2, criteria2, ...)
AVERAGEIF(S)	Same pattern as SUMIF(S)
MAXIFS, MINIFS	MAXIFS(max_range, range1, criteria1, ...)

Note that SUMIF puts the sum range **last** while SUMIFS puts it **first**. Learn the SUMIFS pattern and use it even for one condition.

X Conditional aggregation on Emp			
	A	B	C
1	Question	Result	Formula
2	Employees in Finance	7	=COUNTIF(Emp!C2:C21,"Finance")
3	Finance employees in Delhi	2	=COUNTIFS(Emp!C2:C21,"Finance",Emp!D2:D21,"Delhi")
4	Total Finance salary	670,000	=SUMIFS(Emp!F2:F21,Emp!C2:C21,"Finance")
5	Salary of people rated 4 or more	1,102,000	=SUMIFS(Emp!F2:F21,Emp!G2:G21,">=4")
6	Average salary in HR	96,000	=AVERAGEIFS(Emp!F2:F21,Emp!C2:C21,"HR")
7	Highest salary in Sales	156,000	=MAXIFS(Emp!F2:F21,Emp!C2:C21,"Sales")
8	Joined in 2024 or later	6	=COUNTIFS(Emp!E2:E21,">="&DATE(2024,1,1))
9	Names starting with "A"	4	=COUNTIF(Emp!B2:B21,"A*")
10	Salary between 80k and 1.2 lakh	9	=COUNTIFS(Emp!F2:F21,">=80000",Emp!F2:F21,"<=120000")

B2	=COUNTIF(Emp!C2:C21,"Finance")
B3	=COUNTIFS(Emp!C2:C21,"Finance",Emp!D2:D21,"Delhi")
B4	=SUMIFS(Emp!F2:F21,Emp!C2:C21,"Finance")
B5	=SUMIFS(Emp!F2:F21,Emp!G2:G21,">=4")
B6	=AVERAGEIFS(Emp!F2:F21,Emp!C2:C21,"HR")
B7	=MAXIFS(Emp!F2:F21,Emp!C2:C21,"Sales")
B8	=COUNTIFS(Emp!E2:E21,">="&DATE(2024,1,1))
B9	=COUNTIF(Emp!B2:B21,"A*")
B10	=COUNTIFS(Emp!F2:F21,">=80000",Emp!F2:F21,"<=120000")

Let's confirm two of these with pandas, using the same file:

Python

```
import pandas as pd
emp = pd.read_csv("employees_small.csv", parse_dates=["join_date"])
print("Finance headcount:", (emp.department == "Finance").sum())
print("Total Finance salary:", f"{emp.loc[emp.department == 'Finance', 'salary'].sum():,}")
print("Joined 2024 or later:", (emp.join_date >= "2024-01-01").sum())
```

OUTPUT

Finance headcount: 7

Total Finance salary: 670,000

Joined 2024 or later: 6

Writing criteria correctly

Criteria	Meaning
"Finance"	Equal to Finance (not case-sensitive)
"<>Finance"	Not equal to Finance
" ≥ 4"	Greater than or equal to 4 (operator and number inside quotes)
" ≥ "&H1	Compare with the value in H1 (join with &)
" ≥ "&DATE(2024,1,1)	Compare with a date
"*pune"	Contains "pune"
"A*" / "*a"	Starts with A / ends with a
"?????"	Exactly five characters
" "	Blank cells
"<"	Non-blank cells

TIP Build a summary table with one formula

Put departments in A2:A6 and the formula

=SUMIFS(Emp!\$F\$2:\$F\$21,Emp!\$C\$2:\$C\$21,\$A2) in B2, then copy down. The \$ signs keep the data ranges fixed while \$A2 moves to each department. In Microsoft 365 you can produce the department list itself with =UNIQUE(Emp!C2:C21) (Lesson 6).

X Department summary built with SUMIFS and COUNTIFS

	A	B	C	D	E
1	Department	Headcount	Total salary	Average salary	% of payroll
2	Finance	7	670,000	95,714	33.9%
3	HR	6	576,000	96,000	29.1%
4	IT	1	112,000	112,000	5.7%
5	Operations	2	261,000	130,500	13.2%
6	Sales	4	359,000	89,750	18.1%
7	Total	20	1,978,000	98,900	100.0%

B2 =COUNTIFS(Emp!\$C\$2:\$C\$21,\$A2)

C2 =SUMIFS(Emp!\$F\$2:\$F\$21,Emp!\$C\$2:\$C\$21,\$A2)

D2 =C2/B2

E2 =C2/\$C\$7

B7 =SUM(B2:B6)

C7 =SUM(C2:C6)

E7 =SUM(E2:E6)

Each pattern is copied down/across to the other cells in its column.

This little table is exactly what a pivot table does (Lesson 8), but with formulas you control every cell, which is useful for fixed report layouts.

SUBTOTAL and AGGREGATE: totals for filtered data

SUM adds every row, including rows hidden by a filter. SUBTOTAL adds only **visible** rows, so the total changes as you filter.

=SUBTOTAL(function_num, range)

function_num (ignores filtered rows)	101-111 also ignore manually hidden rows	Function
1	101	AVERAGE
2	102	COUNT
3	103	COUNTA
4	104	MAX
5	105	MIN
9	109	SUM

AGGREGATE does the same and can also **ignore error values**: =AGGREGATE(9, 6, D2:D100) sums D2:D100 ignoring errors (option 6). =AGGREGATE(14, 6, D2:D100, 2) returns the 2nd largest value ignoring errors (14 = LARGE).

X AGGREGATE ignores the #DIV/0! error that breaks SUM

	A	B
1	Value	
2	120	
3	#DIV/0!	
4	80	
5	SUM →	#DIV/0!
6	AGGREGATE(9,6,...) →	200

A3 =10/0

B5 =SUM(A2:A4)

B6 =AGGREGATE(9,6,A2:A4)

Common formula errors and how to fix them

Error	Example	Fix
#DIV/0!	=C2/B2 with B2 = 0	=IFERROR(C2/B2,0) or =IF(B2=0,"",C2/B2)
#VALUE!	=A2+B2 where A2 is text	Convert text to numbers; check for spaces
#REF!	Deleted a referenced row	Undo, or rewrite the formula
#NAME?	=SUMIFS(...,Finance) without quotes	Put text criteria in quotes
Circular reference	=SUM(A1:A10) typed in A10	Move the total outside the range
Wrong total after sorting	Mixed relative/absolute references	Lock ranges with \$

Formulas → **Formula Auditing** helps: **Trace Precedents** draws arrows to the cells a formula uses, **Trace Dependents** to cells that use it, **Show Formulas** (Ctrl + `) shows every formula, and **Evaluate Formula** steps through a calculation (Lesson 11).

DO IT WITH AI Do it with AI

Paste a formula into Copilot or a chat assistant and ask: *"Explain this Excel formula step by step and tell me what would make it return an error:*

=SUMIFS(Sales!\$F:\$F, Sales!\$C:\$C, \$A2, Sales!\$E:\$E, " ≥ "&\$B\$1)." Use AI to explain and draft formulas, then check the result on a few rows you can verify by hand.

Summary

KEY TAKEAWAYS

- Formula = any calculation starting with =; function = a named calculation such as SUM.
- Order: brackets, power, multiply/divide, add/subtract, join, compare. In Excel $-2^2 = 4$.
- \$ locks a reference; **F4** cycles relative → absolute → mixed. Mixed references build 2-D tables with one formula.
- COUNT counts numbers; COUNTA counts non-empty; COUNTBLANK counts empty.
- SUMIFS(sum_range, criteria_range, criteria, ...) and COUNTIFS answer most business questions.
- Criteria with operators go in quotes and join cell values with &: " ≥ "&H1.
- SUBTOTAL(109, ...) sums only visible rows; AGGREGATE can also ignore errors.

Quick quiz

6 questions · tap an answer to check it

1. You copy $=B2*\$E\1 from C2 to C5. What is the formula in C5?

A $=B5*\$E\4

B $=B5*\$E\1

C $=B2*\$E\1

D $=E5*\$B\1

Answer: B. B2 is relative and moves to B5; $\$E\1 is absolute and stays.

2. Which formula, typed in B2 and copied across and down, builds a multiplication table with headers in row 1 and column A?

A $=A2*B1$

B $=\$A\$2*\$B\1

C $=\$A2*B\1

D $=A\$2*\$B1$

Answer: C. Column A is locked for the row header, and row 1 is locked for the column header.

3. A range contains 10, "abc", blank, 25, TRUE (typed). What does COUNT return?

A 2

B 3

C 4

D 5

Answer: A. COUNT counts only numbers in a range: 10 and 25.

4. Which formula totals Sales (D) where Region (B) is "North" AND Category (C) is "Technology"?

A =SUMIF(B:B,"North",D:D)

B =SUMIFS(D:D,B:B,"North",C:C,"Technology")

C =SUMIFS(B:B,"North",C:C,"Technology",D:D)

D =COUNTIFS(B:B,"North",C:C,"Technology")

Answer: B. SUMIFS takes the sum range first, then pairs of criteria range and criteria.

5. How do you count values in A2:A100 greater than the value in H1?

A =COUNTIF(A2:A100,>H1)

B =COUNTIF(A2:A100,">H1")

C =COUNTIF(A2:A100,">"&H1)

D =COUNTIF(A2:A100,H1>)

Answer: C. The operator is text and is joined to the cell value with &.

6. You filter a table to show only Pune. Which total updates to show only Pune's sales?

A =SUM(D2:D500)

B =SUBTOTAL(109,D2:D500)

C =SUMIF(D2:D500,">0")

D =AGGREGATE(9,0,D2:D500) with option 0

Answer: B. SUBTOTAL 9/109 ignores rows hidden by a filter.

EXERCISE Superstore questions with formulas

Open `superstore_sales.csv` in Excel. Using only aggregate and IFS functions, find: (1) total sales; (2) number of order lines in the West region; (3) total profit for Technology in 2025; (4) average discount for Furniture; (5) the largest single order-line sale in the South.

Show solution (worked answer)

Assuming columns: J region, L category, O sales, Q discount, R profit and B order_date (check your own column letters): (1) `=SUM(O:O)` (2) `=COUNTIFS(J:J, "West")` (3) `=SUMIFS(R:R, L:L, "Technology", B:B, ">= "&DATE(2025,1,1), B:B, "<="&DATE(2025,12,31))` (4) `=AVERAGEIFS(Q:Q, L:L, "Furniture")` (5) `=MAXIFS(O:O, J:J, "South")` Check your answers in Python with pandas (Python track, Lesson 22) or with a pivot table (Lesson 8): they must match exactly.

INTERVIEW CORNER Questions you may be asked

Q: What is the difference between COUNT, COUNTA and COUNTBLANK? COUNT counts numeric cells, COUNTA counts every non-empty cell (including text and formulas returning ""), COUNTBLANK counts empty cells and cells containing "".

Q: When would you use a mixed reference? When a formula is copied in two directions and must keep either the row or the column fixed, for example a price × quantity grid or a commission table: `=A2*B$1`.

Q: Why use SUMIFS instead of SUMIF? SUMIFS supports multiple conditions, has a consistent argument order (sum range first), and works for one condition too, so one pattern covers every case.

Q: How do you total only visible rows after filtering? Use `SUBTOTAL(109, range)` or `AGGREGATE(9, 5, range)`; the Table Total Row does this automatically.

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