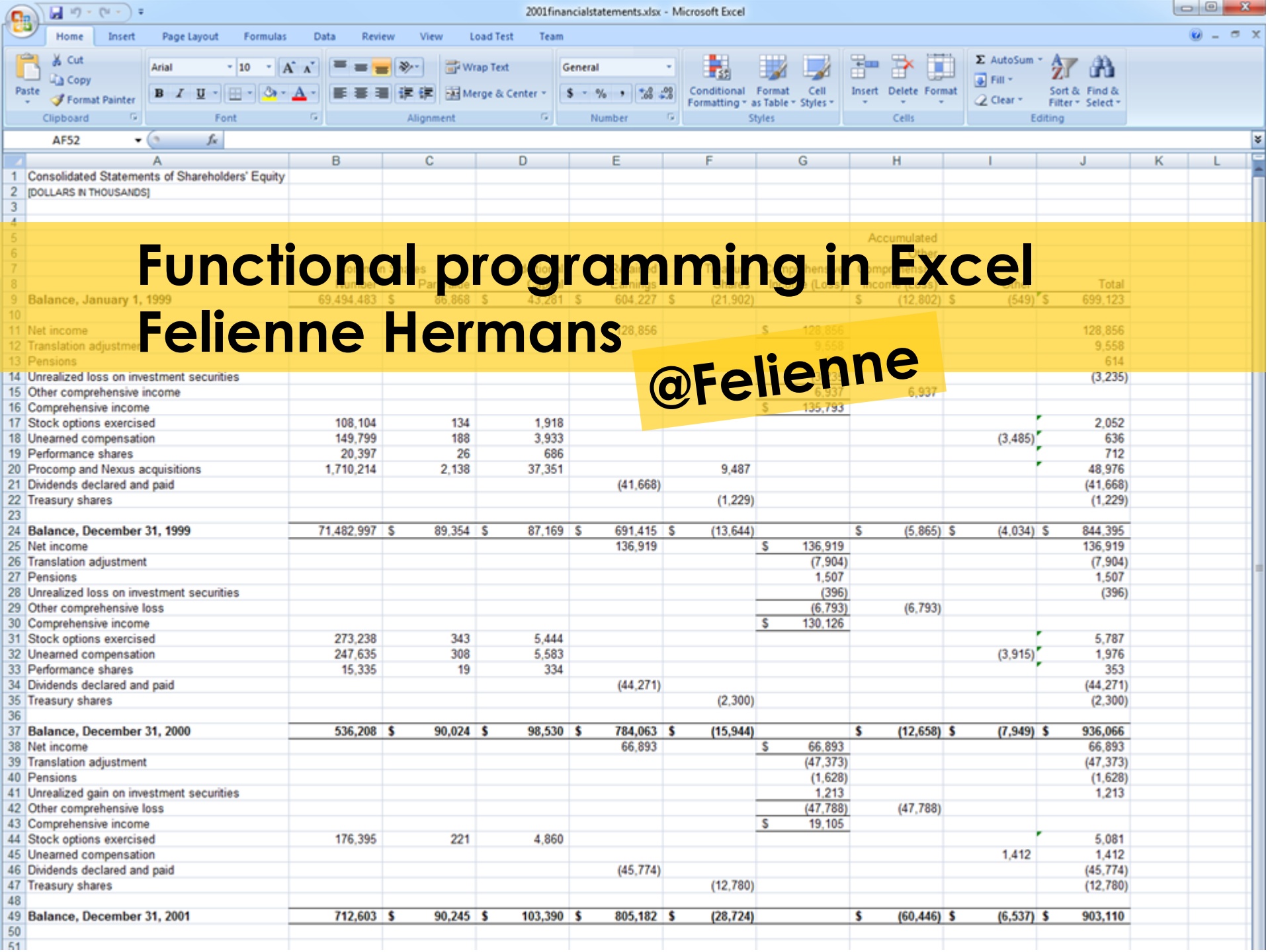

Functional programming in Excel

Felienne Hermans

@Felienne

2001financialstatements.xlsx - Microsoft Excel

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AF52

Consolidated Statements of Shareholders' Equity
[DOLLARS IN THOUSANDS]

	Common Shares Number	Common Shares Value	Additional Capital	Retained Earnings	Treasury Shares	Comprehensive Income (Loss)	Accumulated Other Comprehensive Income (Loss)	Other	Total
Balance, January 1, 1999	69,494,483	6,868	$ 43,281	$ 604,227	$ (21,902)		$ (12,802)	$ (549)	$ 699,123
Net income				128,856		$ 128,856			128,856
Translation adjustment						9,558			9,558
Pensions						614			614
Unrealized loss on investment						(3,235)			(3,235)
Other comprehensive income						6,937	6,937		
Comprehensive income						$ 135,793			
Stock options exercised			1,918						2,052
Unearned compensation			3,933					(3,485)	636
Performance shares			686						712
Procomp and Nexus a			37,351		9,487				48,976
Dividends declared				(41,668)					(41,668)
Treasury shares					(1,229)				(1,229)
Balance			87,169	$ 691,415	$ (13,644)		$ (5,865)	$ (4,034)	$ 844,395
Net in				136,919		$ 136,919			136,919
Trans						(7,904)			(7,904)
Pensio						1,507			1,507
Unreali						(396)			(396)
Other c						(6,793)	(6,793)		
Comprehe						$ 130,126			
Stock optio		343	5,444						5,787
Unearned comp		308	5,583					(3,915)	1,976
Performance shares		19	334						353
Dividends declared and pa				(44,271)					(44,271)
Treasury shares					(2,300)				(2,300)
Balance, December 31, 2000		$ 90,024	$ 98,530	$ 784,063	$ (15,944)		$ (12,658)	$ (7,949)	$ 936,066
Net income				66,893		$ 66,893			66,893
Translation adjustment						(47,373)			(47,373)
Pensions						(1,628)			(1,628)
Unrealized gain on investment securities						1,213			1,213
Other comprehensive loss						(47,788)	(47,788)		
Comprehensive income						$ 19,105			
Stock options exercised	176,395	221	4,860						5,081
Unearned compensation								1,412	1,412
Dividends declared and paid				(45,774)					(45,774)
Treasury shares					(12,780)				(12,780)
Balance, December 31, 2001	712,603	$ 90,245	$ 103,390	$ 805,182	$ (28,724)		$ (60,446)	$ (6,537)	$ 903,110

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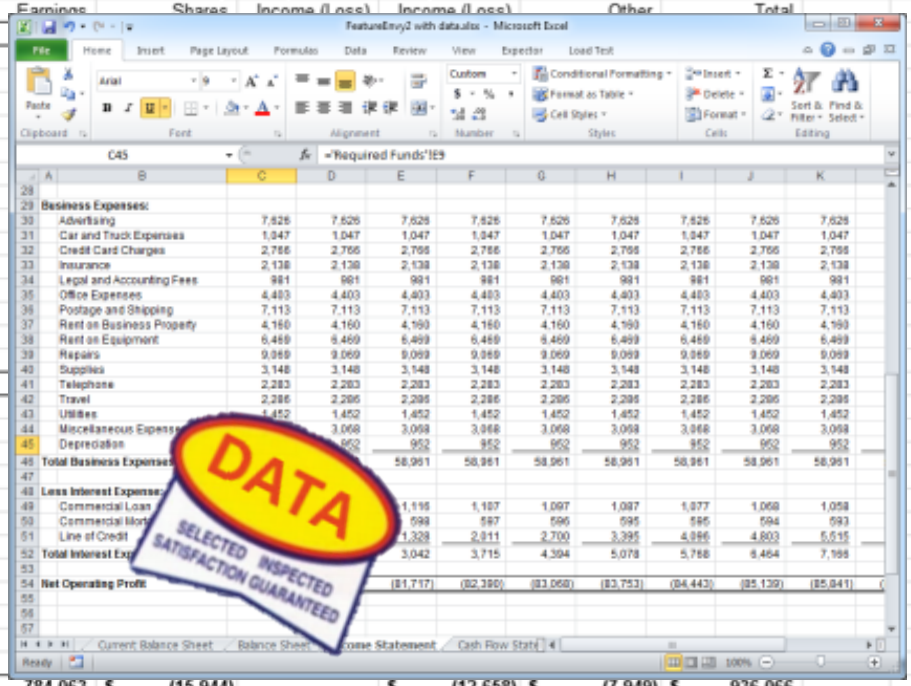
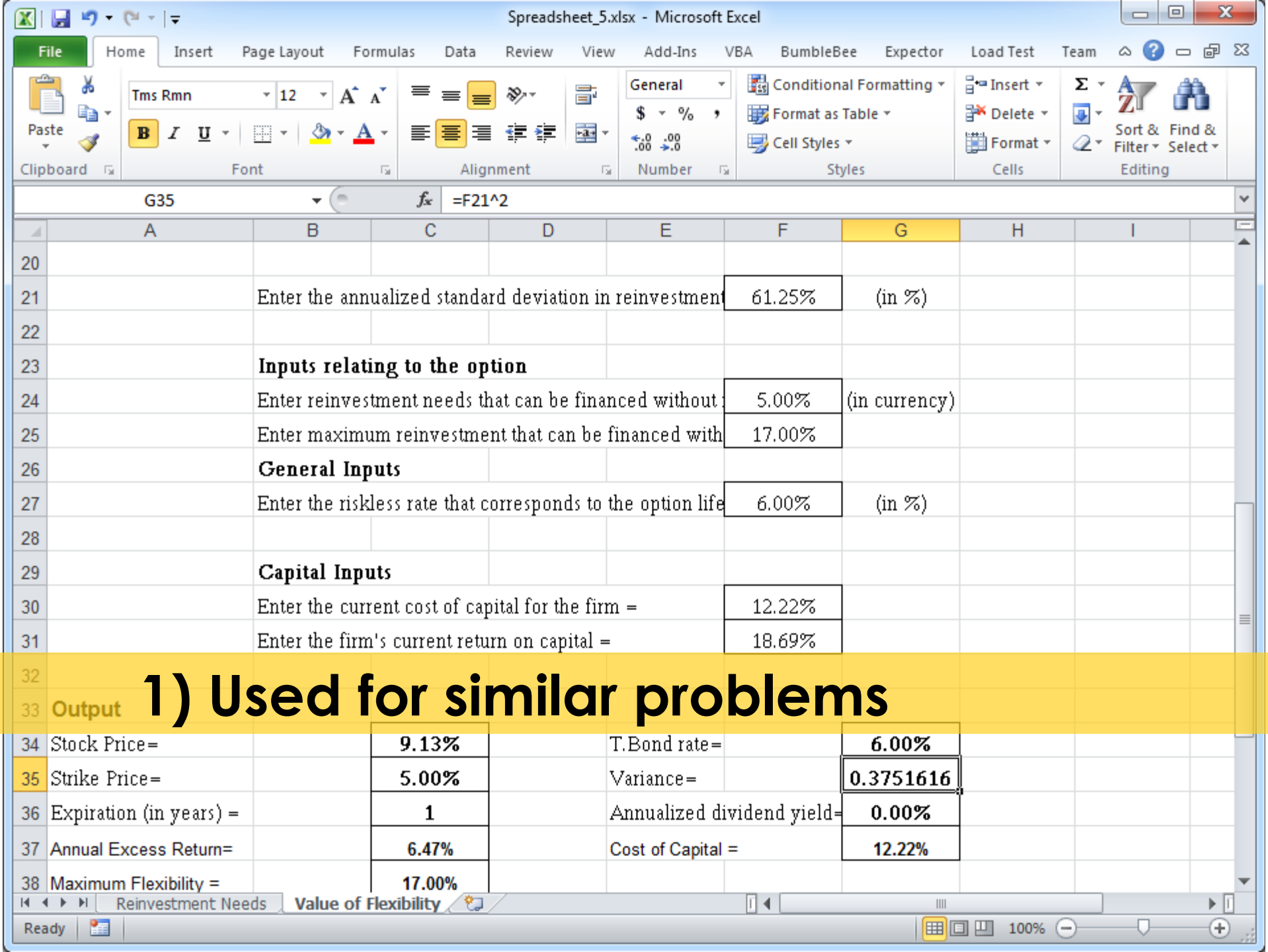
AF52

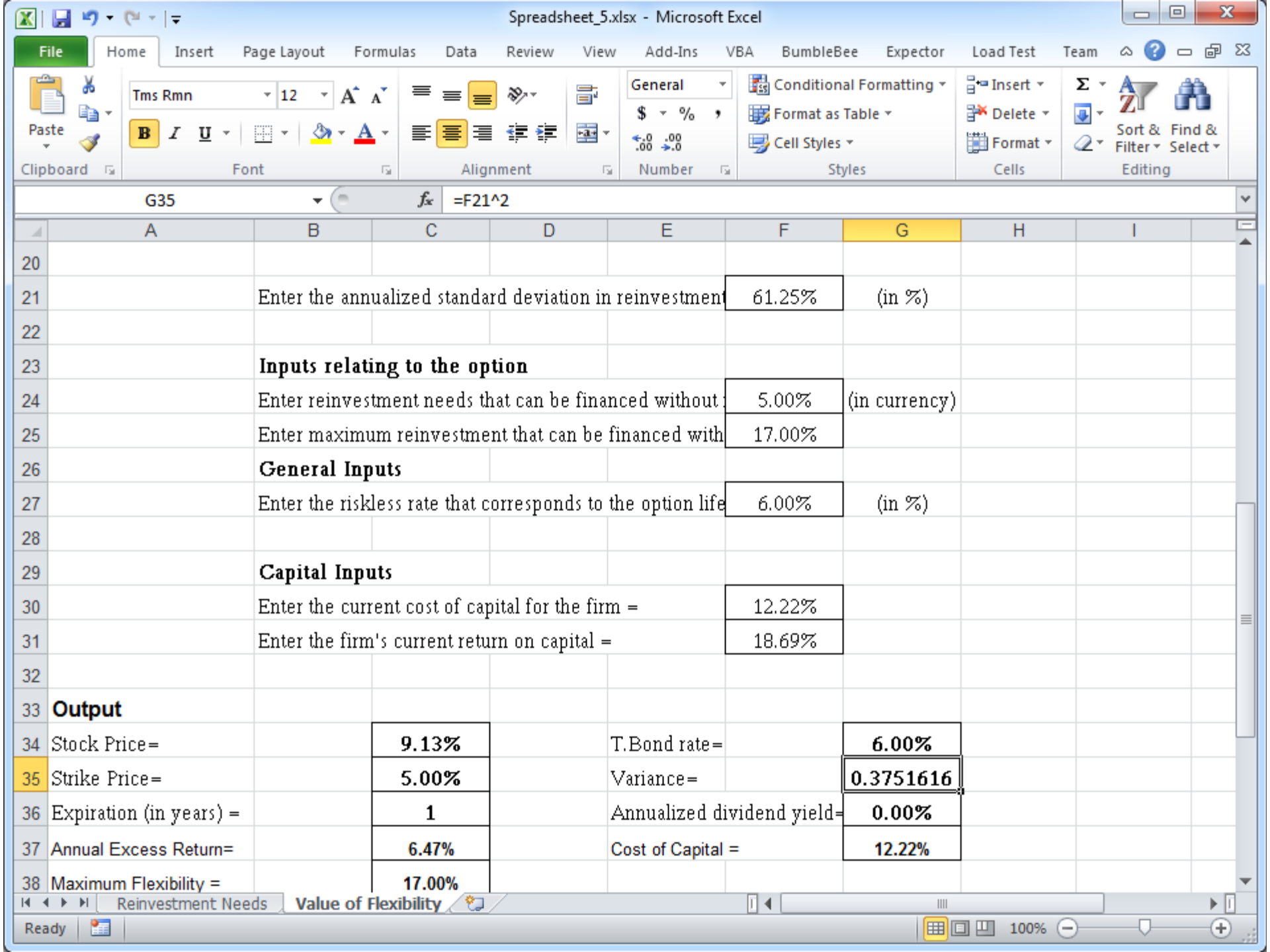
	A	B	C	D	E	F	G	H	I	J	K	L
1	Consolidated Statements of Shareholders' Equity											
2	[DOLLARS IN THOUSANDS]											
3												
4												
5								Accumulated				
6								Other				
7		Common Shares		Additional	Retained	Treasury	Comprehensive	Comprehensive				
8		Number	Value	Capital	Earnings	Shares	Income (Loss)	Income (Loss)	Other	Total		
9	**Balance, January 1, 1999**	69,494,483	6,868	$ 43,281	$							
10												
11	Net income											
12	Translation adjustment											
13	Pensions											
14	Unrealized loss on investment											
15	Other comprehensive income											
16	Comprehensive income											
17	Stock options exercised			1,918								
18	Unearned compensation			3,933								
19	Performance shares			686								
20	Procomp and Nexus a			37,351								
21	Dividends declared											
22	Treasury shares											
23												
24	**Balance**			87,169	$							
25	Net in											
26	Trans											
27	Pensio											
28	Unreali											
29	Other c											
30	Compreh											
31	Stock optio		343	5,444								
32	Unearned comp		308	5,583								
33	Performance shares		19	334								
34	Dividends declared and pa											
35	Treasury shares											
36												
37	**Balance, December 31, 2000**		$ 90,024	$ 98,530	$ 784,063	$ (15,944)		$ (12,658)	$ (7,949)	$ 936,066		
38	Net income				66,893		$ 66,893			66,893		
39	Translation adjustment						(47,373)			(47,373)		
40	Pensions						(1,628)			(1,628)		
41	Unrealized gain on investment securities						1,213			1,213		
42	Other comprehensive loss						(47,788)	(47,788)				
43	Comprehensive income						$ 19,105					
44	Stock options exercised	176,395	221	4,860						5,081		
45	Unearned compensation								1,412	1,412		
46	Dividends declared and paid				(45,774)					(45,774)		
47	Treasury shares					(12,780)				(12,780)		
48												
49	**Balance, December 31, 2001**	712,603	$ 90,245	$ 103,390	$ 805,182	$ (28,724)		$ (60,446)	$ (6,537)	$ 903,110		
50												



Spreadsheets are code



1) Used for similar problems



Spreadsheet_5.xlsx - Microsoft Excel

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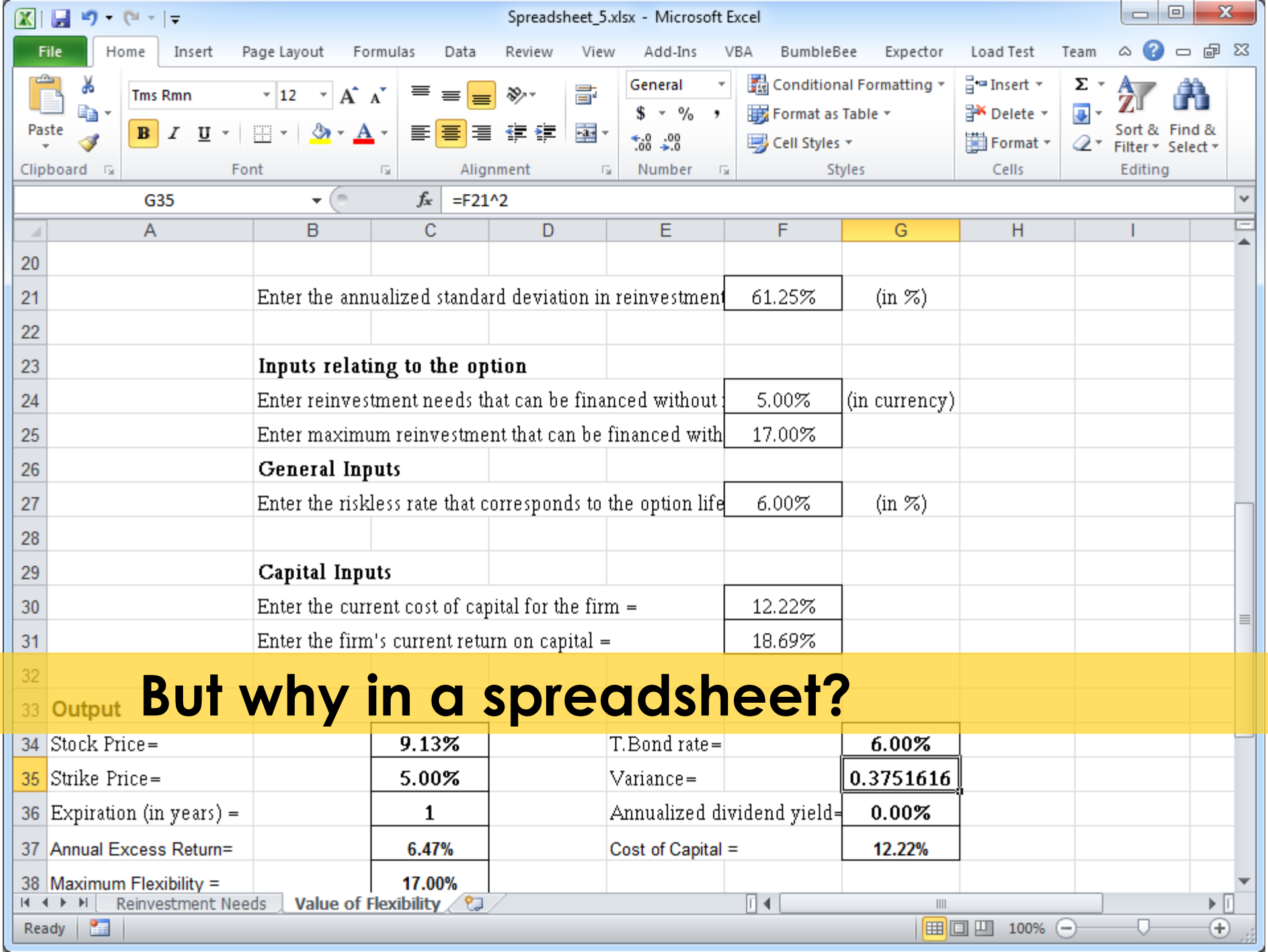
G35 =F21^2

	A	B	C	D	E	F	G	H	I
20									
21		Enter the annualized standard deviation in reinvestment				61.25%	(in %)		
22									
23		**Inputs relating to the option**							
24		Enter reinvestment needs that can be financed without				5.00%	(in currency)		
25		Enter maximum reinvestment that can be financed with				17.00%			
26		**General Inputs**							
27		Enter the riskless rate that corresponds to the option life				6.00%	(in %)		
28									
29		**Capital Inputs**							
30		Enter the current cost of capital for the firm =				12.22%			
31		Enter the firm's current return on capital =				18.69%			
32									
33	**Output**								
34	Stock Price=		9.13%		T.Bond rate=		6.00%		
35	Strike Price=		5.00%		Variance=		0.3751616		
36	Expiration (in years) =		1		Annualized dividend yield=		0.00%		
37	Annual Excess Return=		6.47%		Cost of Capital =		12.22%		
38	Maximum Flexibility =		17.00%						

Reinvestment Needs | Value of Flexibility

Ready 100%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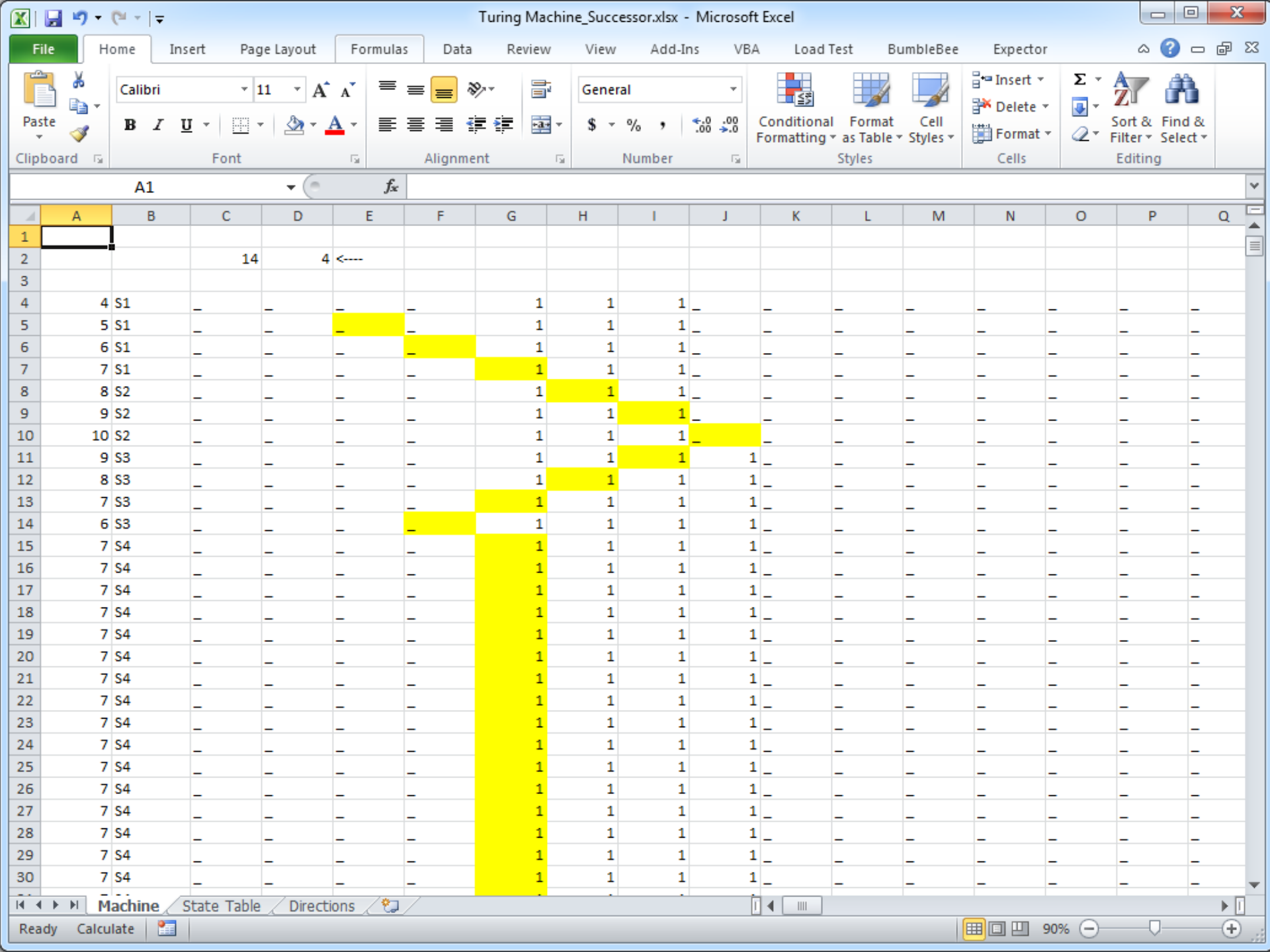
20
21 Enter the annualized standard deviation in reinvestment 61.25% (in %)
22
23 Inputs relating to the option
24 Enter reinvestment needs that can be financed without 5.00% (in currency)
25 Enter maximum reinvestment that can be financed with 17.00%
26 General Inputs
27 Enter the riskless rate that corresponds to the option life 6.00% (in %)
28
29 Capital Inputs
30 Enter the current cost of capital for the firm = 12.22%
31 Enter the firm's current return on capital = 18.69%
32
33 Output
34 Stock Price= 9.13% T.Bond rate= 6.00%
35 Strike Price= 5.00% Variance= 0.3751616
36 Expiration (in years) = 1 Annualized dividend yield= 0.00%
37 Annual Excess Return= 6.47% Cost of Capital = 12.22%
38 Maximum Flexibility = 17.00%
But why in a spreadsheet?
Reinvestment Needs
Value of Flexibility
Ready
100%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Ready
Calculate
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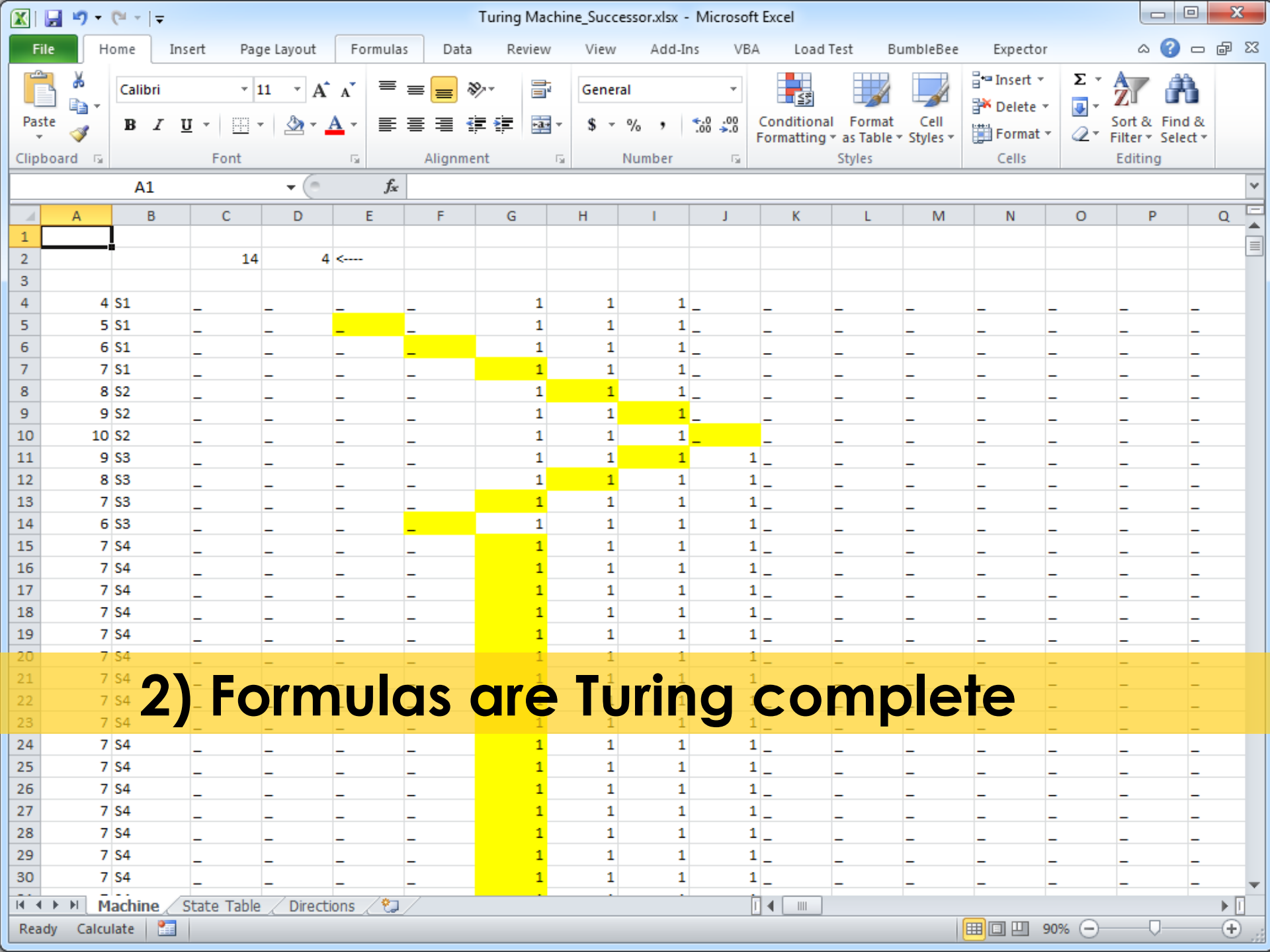
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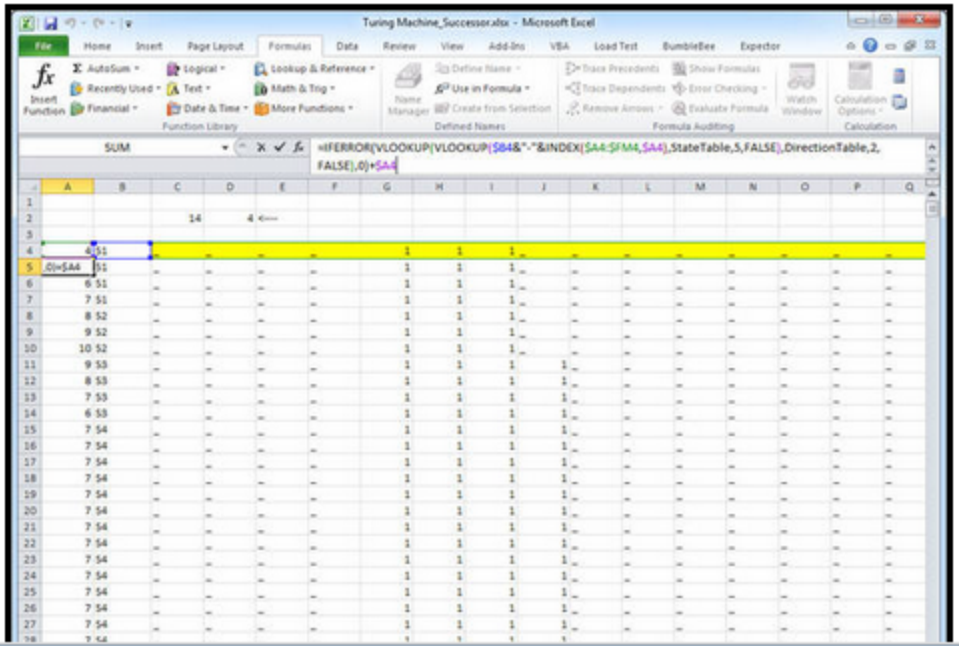
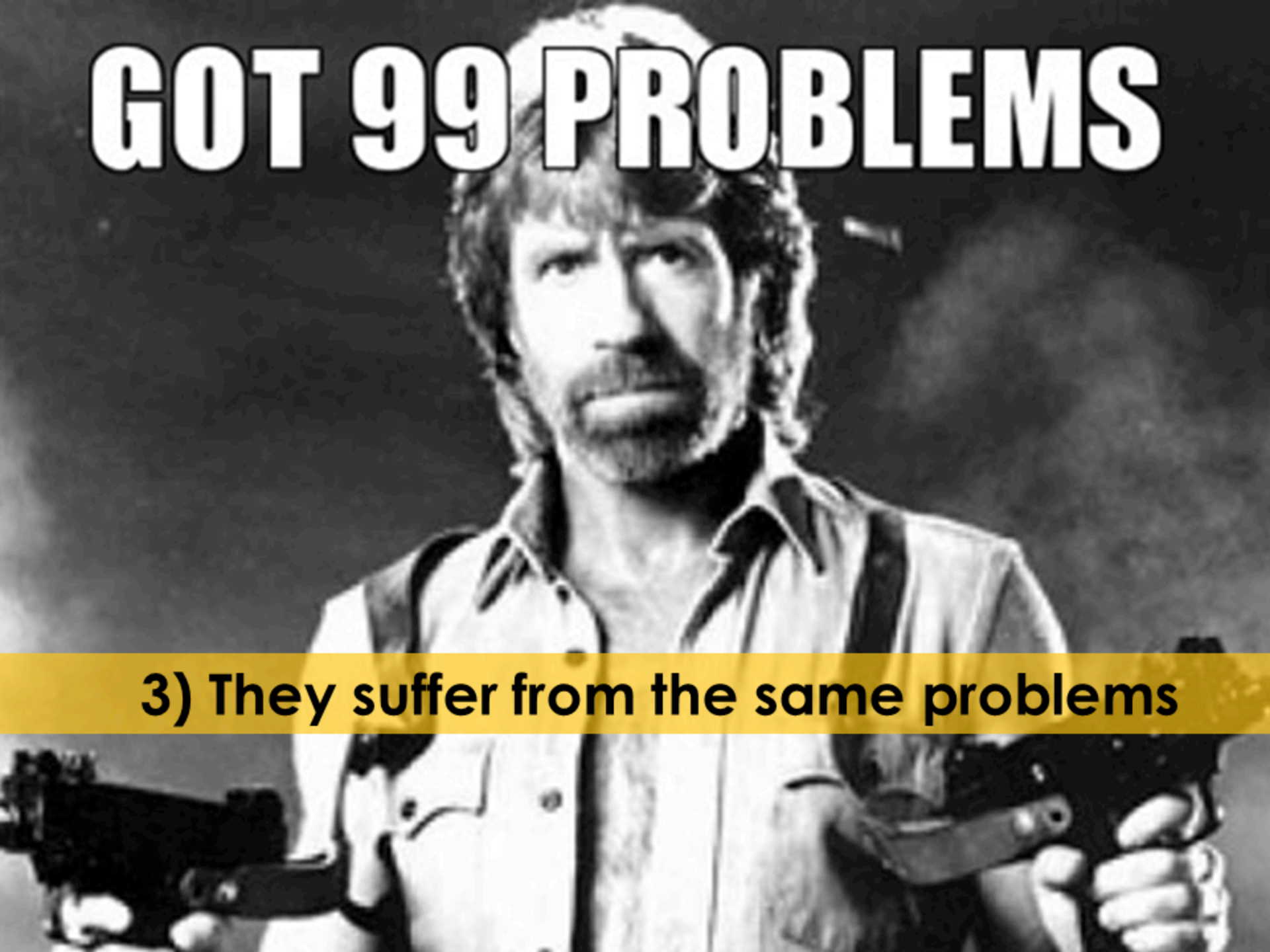
90%
2) Formulas are Turing complete

boing boing

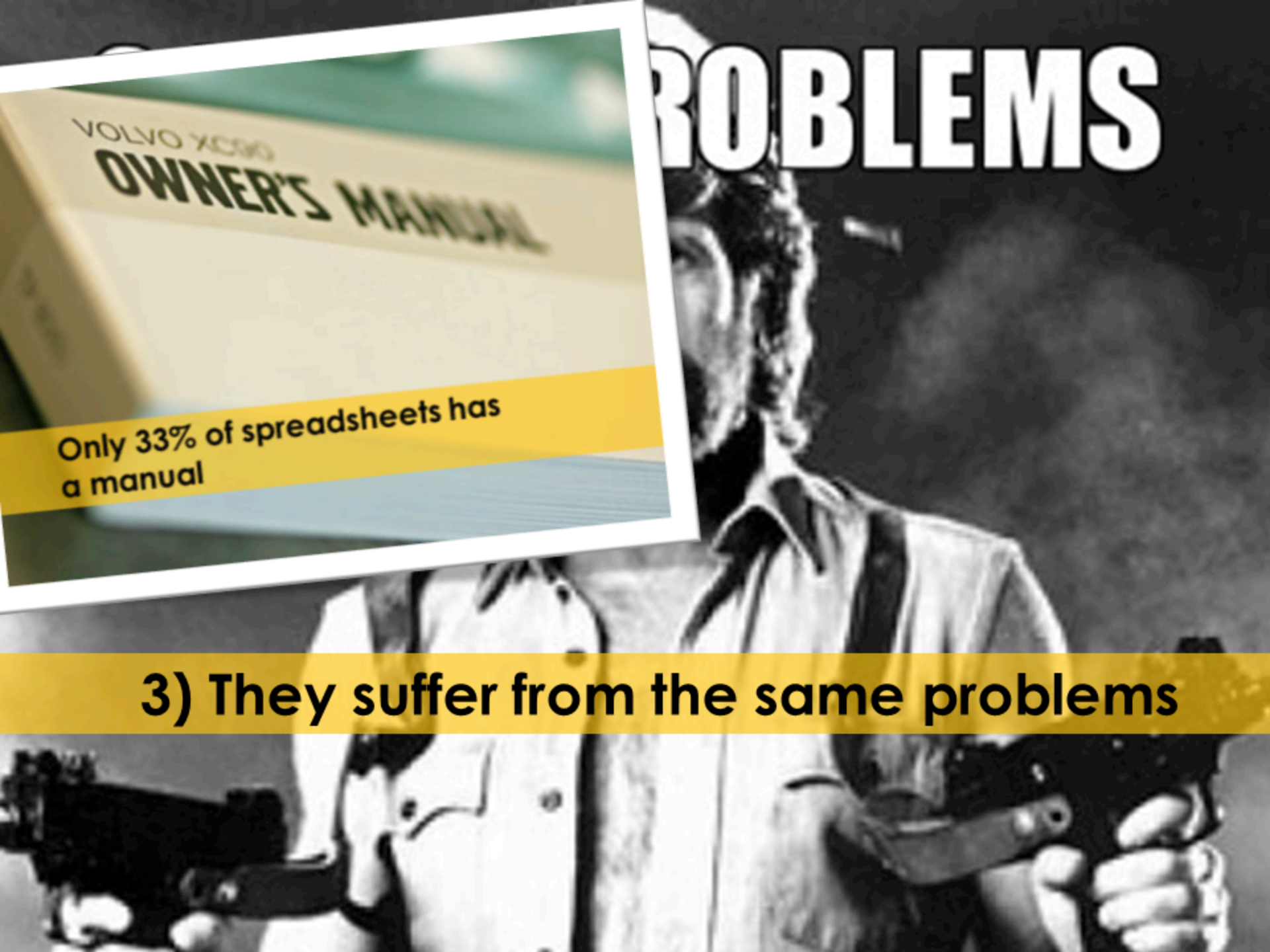
Implementing a Turing machine in Excel

Cory Doctorow at 2:20 pm Fri, Sep 20, 2013





3) They suffer from the same problems


VOLVO XC90
OWNER'S MANUAL
Only 33% of spreadsheets has a manual
ROBLEMS
3) They suffer from the same problems


VOLVO
OWNE
Only 33% o
a manual
Average sheet is used by 12 different people
3) They suffer from the same problems

3) They suffer from the same problems

In summary: both the activities, complexity and problems are the same

Spreadsheets are code

In summary: both the activities, complexity and problems are the same

And not just a programming language!

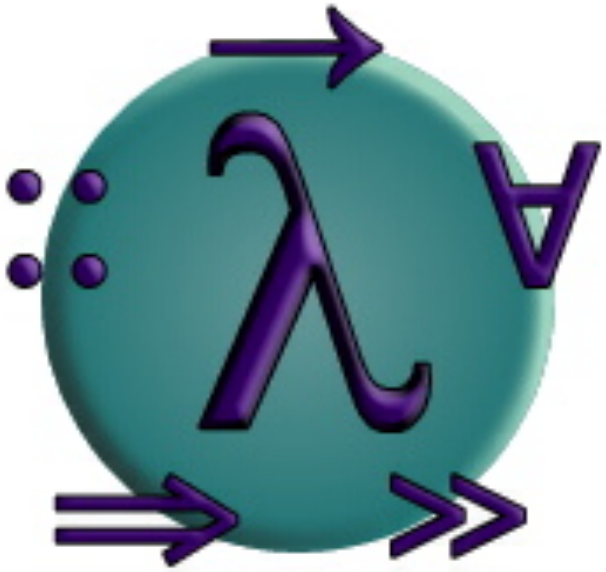
	A	B	C	D	E	F	G	H	I	J	K	L
1	Consolidated Statements of Shareholders' Equity											
2	[DOLLARS IN THOUSANDS]											
3												
4												
5										Accumulated		
6												
7												
8		Number	Par Value	Capital	Earnings	Shares	Income (Loss)	Income (Loss)	Other	Total		
9	**Balance, January 1, 1999**	69,494,483	$ 86,868	$ 43,281	$ 604,227	$ (21,902)		$ (12,802)	$ (549)	$ 699,123		
10												
11	Net income				128,856		$ 128,856			128,856		
12	Translation adjustment						9,558			9,558		
13	Pensions						614			614		
14	Unrealized loss on investment securities						(3,235)			(3,235)		
15	Other comprehensive income						6,937	6,937				
16	Comprehensive income						$ 135,793					
17	Stock options exercised	108,104	134	1,918						2,052		
18	Unearned compensation	149,799	188	3,933					(3,485)	636		
19	Performance shares	20,397	26	686						712		
20	Procomp and Nexus acquisitions	1,710,214	2,138	37,351		9,487				48,976		
21	Dividends declared and paid				(41,668)					(41,668)		
22	Treasury shares					(1,229)				(1,229)		
23												
24	**Balance, December 31, 1999**	71,482,997	$ 89,354	$ 87,169	$ 691,415	$ (13,644)		$ (5,865)	$ (4,034)	$ 844,395		
25	Net income				136,919		$ 136,919			136,919		
26	Translation adjustment						(7,904)			(7,904)		
27	Pensions						1,507			1,507		
28	Unrealized loss on investment securities						(396)			(396)		
29	Other comprehensive loss						(6,793)	(6,793)				
30	Comprehensive income						$ 130,126					
31	Stock options exercised	273,238	343	5,444						5,787		
32	Unearned compensation	247,635	308	5,583					(3,915)	1,976		
33	Performance shares	15,335	19	334						353		
34	Dividends declared and paid				(44,271)					(44,271)		
35	Treasury shares					(2,300)				(2,300)		
36												
37	**Balance, December 31, 2000**	536,208	$ 90,024	$ 98,530	$ 784,063	$ (15,944)		$ (12,658)	$ (7,949)	$ 936,066		
38	Net income				66,893		$ 66,893			66,893		
39	Translation adjustment						(47,373)			(47,373)		
40	Pensions						(1,628)			(1,628)		
41	Unrealized gain on investment securities						1,213			1,213		
42	Other comprehensive loss						(47,788)	(47,788)				
43	Comprehensive income						$ 19,105					
44	Stock options exercised	176,395	221	4,860						5,081		
45	Unearned compensation								1,412	1,412		
46	Dividends declared and paid				(45,774)					(45,774)		
47	Treasury shares					(12,780)				(12,780)		
48												
49	**Balance, December 31, 2001**	712,603	$ 90,245	$ 103,390	$ 805,182	$ (28,724)		$ (60,446)	$ (6,537)	$ 903,110		
50												
51												


The next language to learn
Resistance is futile!

live programming

```
    canvasHeight = parseInt(canvas.getAttribute("height"));

    drawSky();
    drawMountains();
    drawTree();
}


//--------------------------------------------------------
//
//  sky
//

function drawSky () {
    ctx.save();

    var gradient = ctx.createLinearGradient(0,0,0,canvasHeight);
    gradient.addColorStop(0, "#b4e0fe");
    gradient.addColorStop(1, "#d3f8ff");

    ctx.fillStyle = gradient;
    ctx.fillRect(0,0,canvasWidth,canvasHeight);

    ctx.restore();
}



//--------------------------------------------------------
//
//  mountains
//

function drawMountains () {
    resetRandom();

    drawMountain(130, "#8bb2bb");
    drawMountain(50, "#618087");
}
```

pure functional



Haskell

A Purely Functional Language

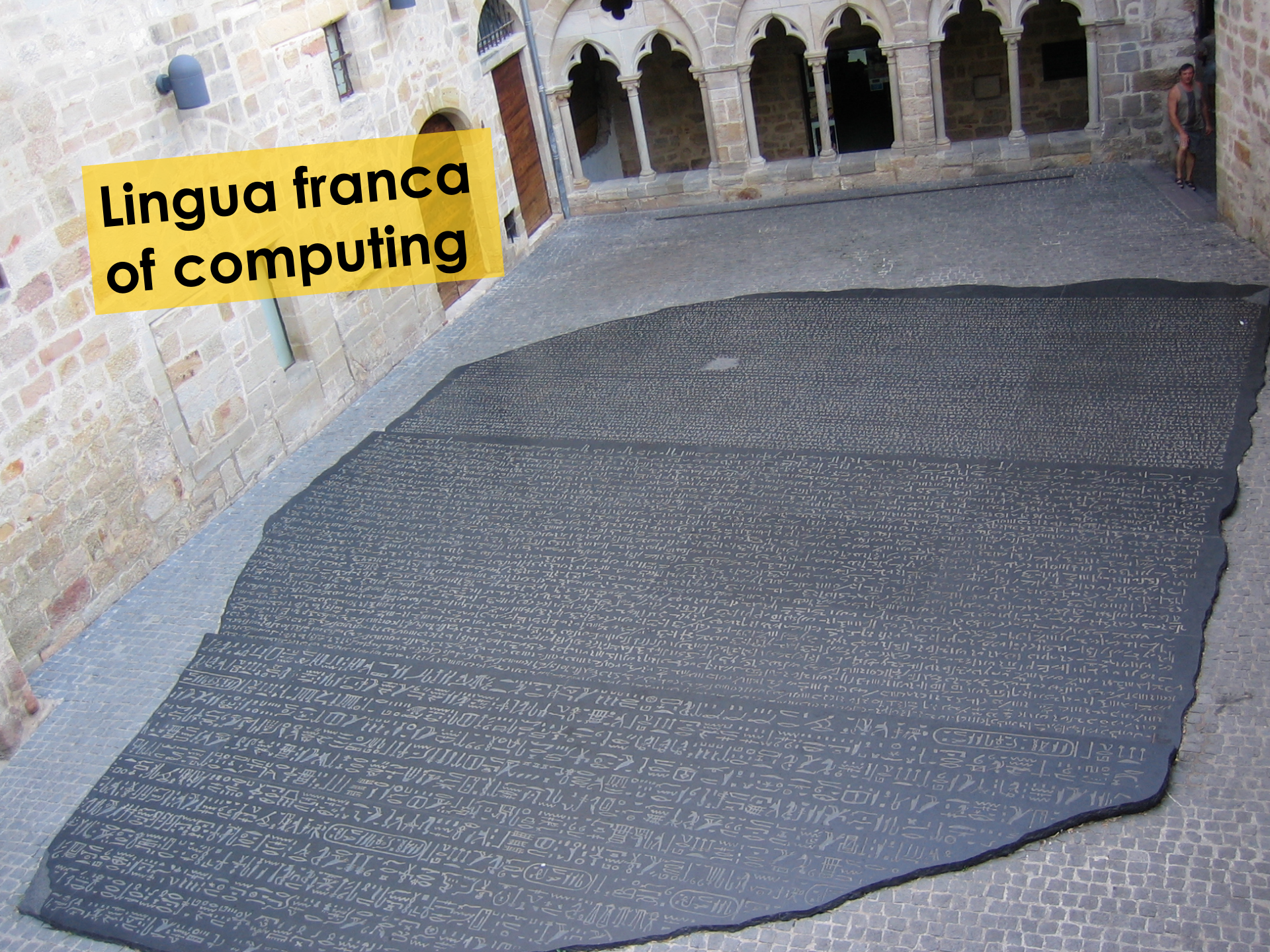
featuring static typing, higher-order functions, polymorphism, type classes and monadic effects

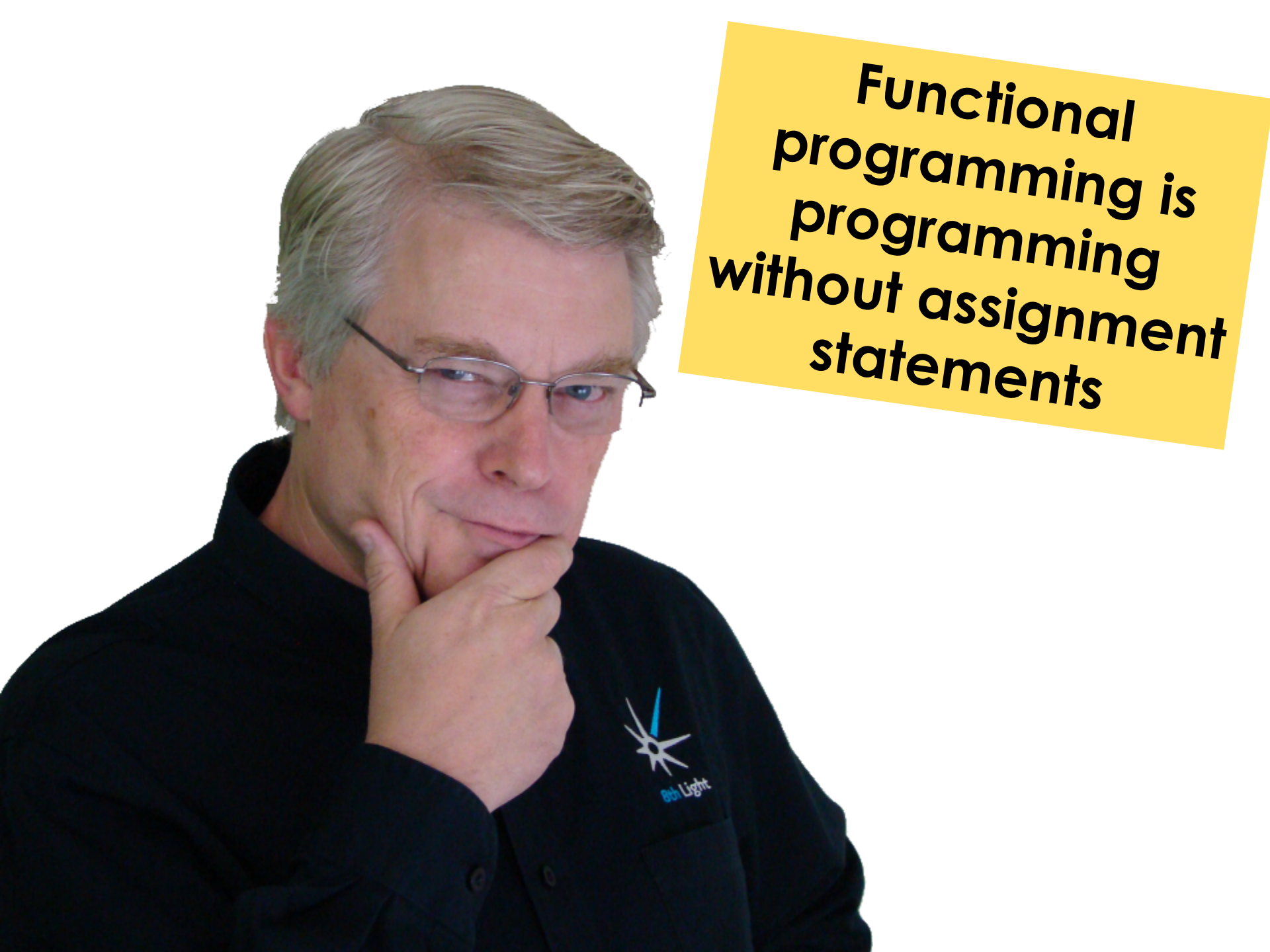
pure functional

Excel

A Purely Functional Language

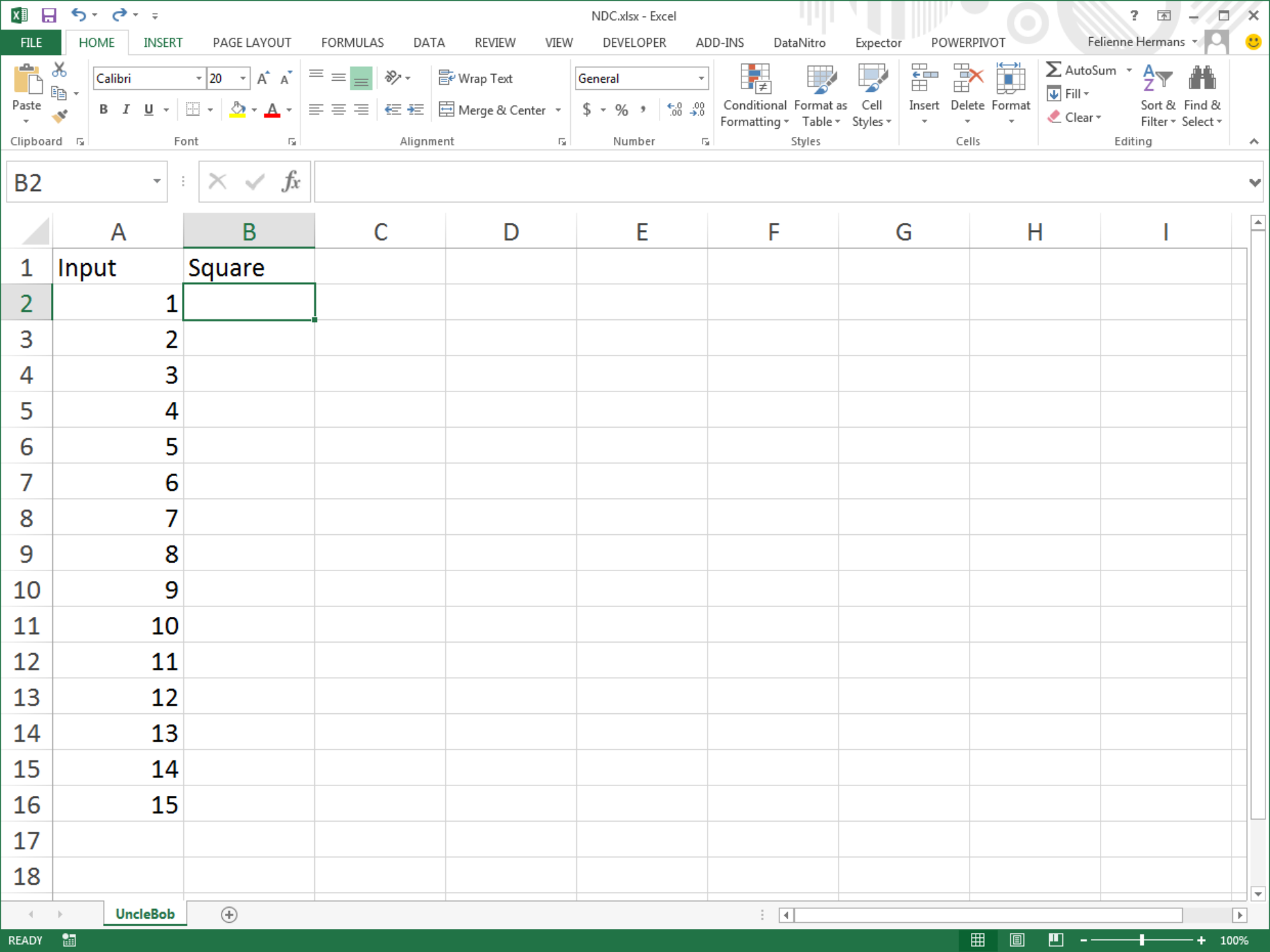
featuring static typing, higher-order functions,
polymorphism, type classes and monadic effects


Lingua franca
of computing


Functional programming is programming without assignment statements

Functional programming is programming without assignment statements

Example: Squares of integers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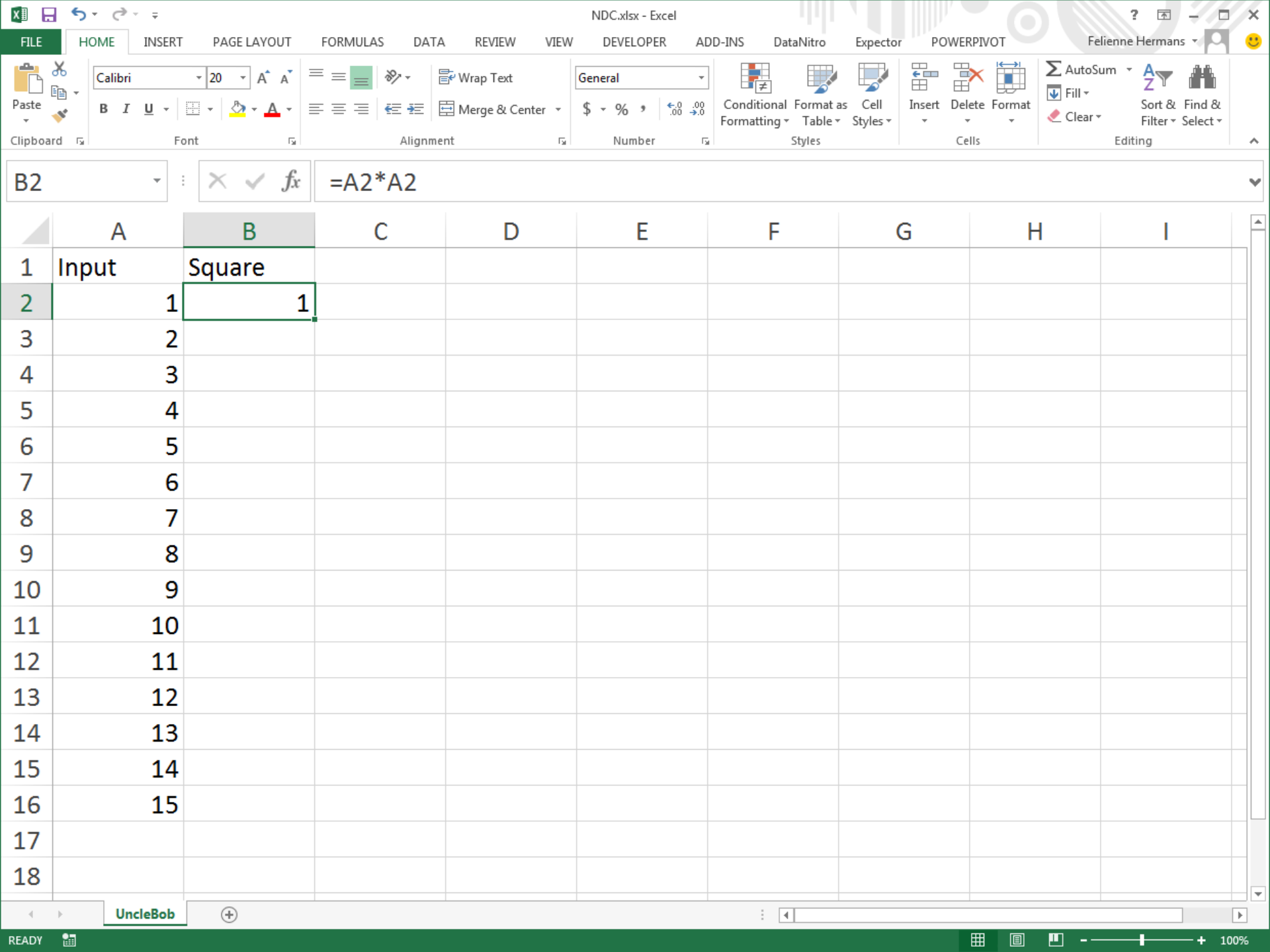
I
1 Input Square
2 1
3 2
4 3
5 4
6 5
7 6
8 7
9 8
10 9
11 10
12 11
13 12
14 13
15 14
16 15
17
18
UncleBob
READY
100%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=A2*A2
A
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I
1 Input Square
2 1 1
3 2
4 3
5 4
6 5
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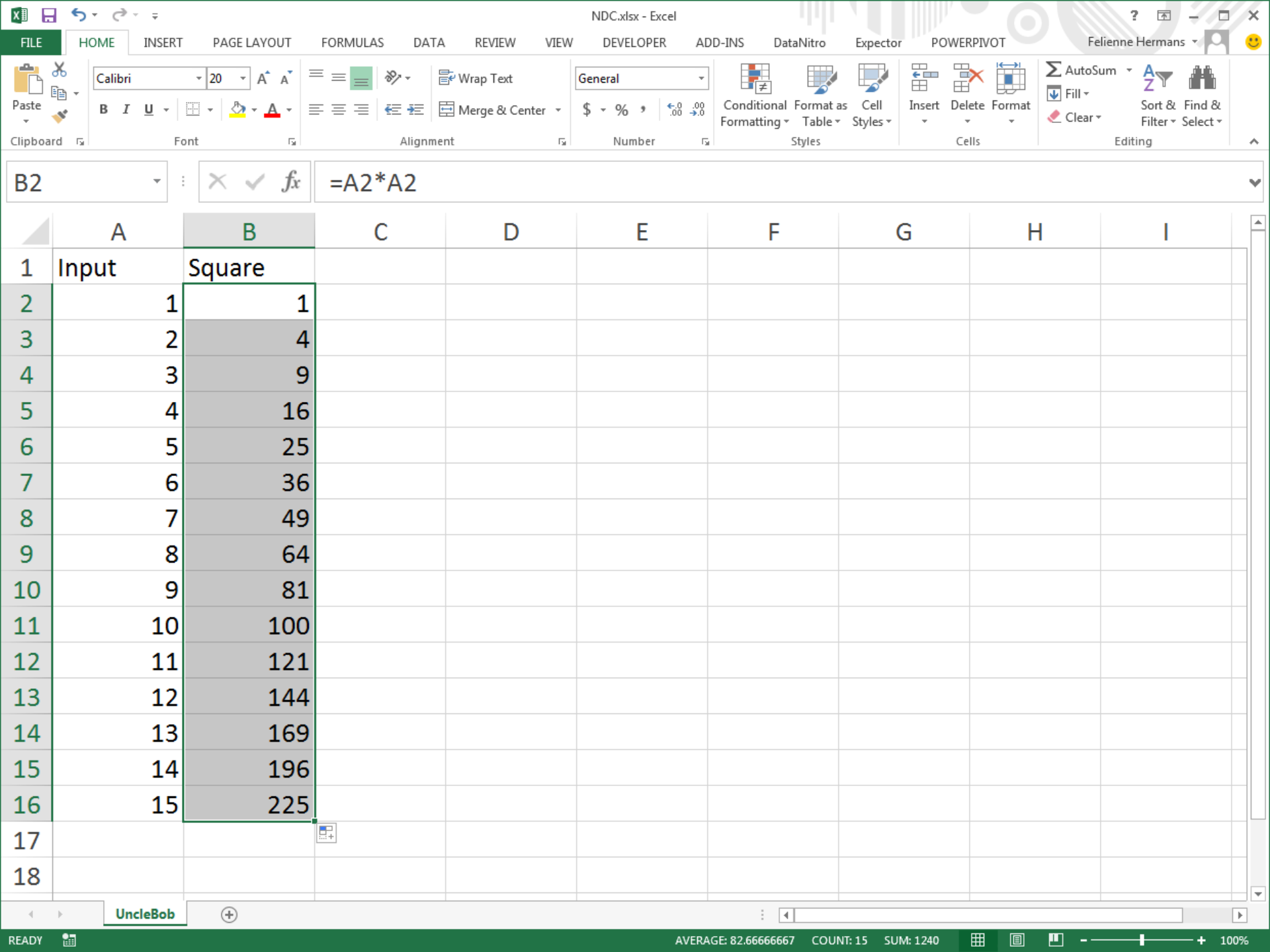
UncleBob
READY
100%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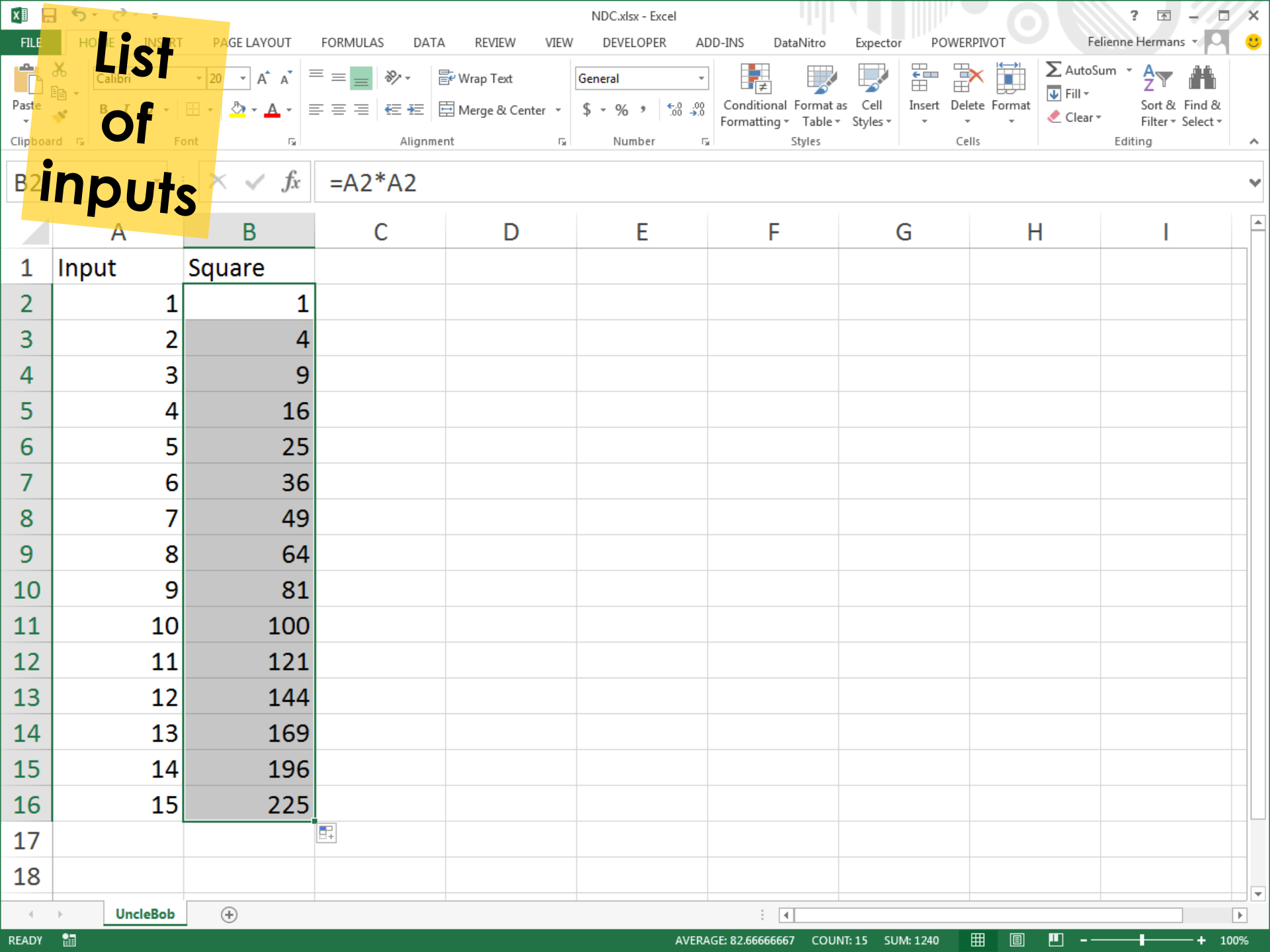
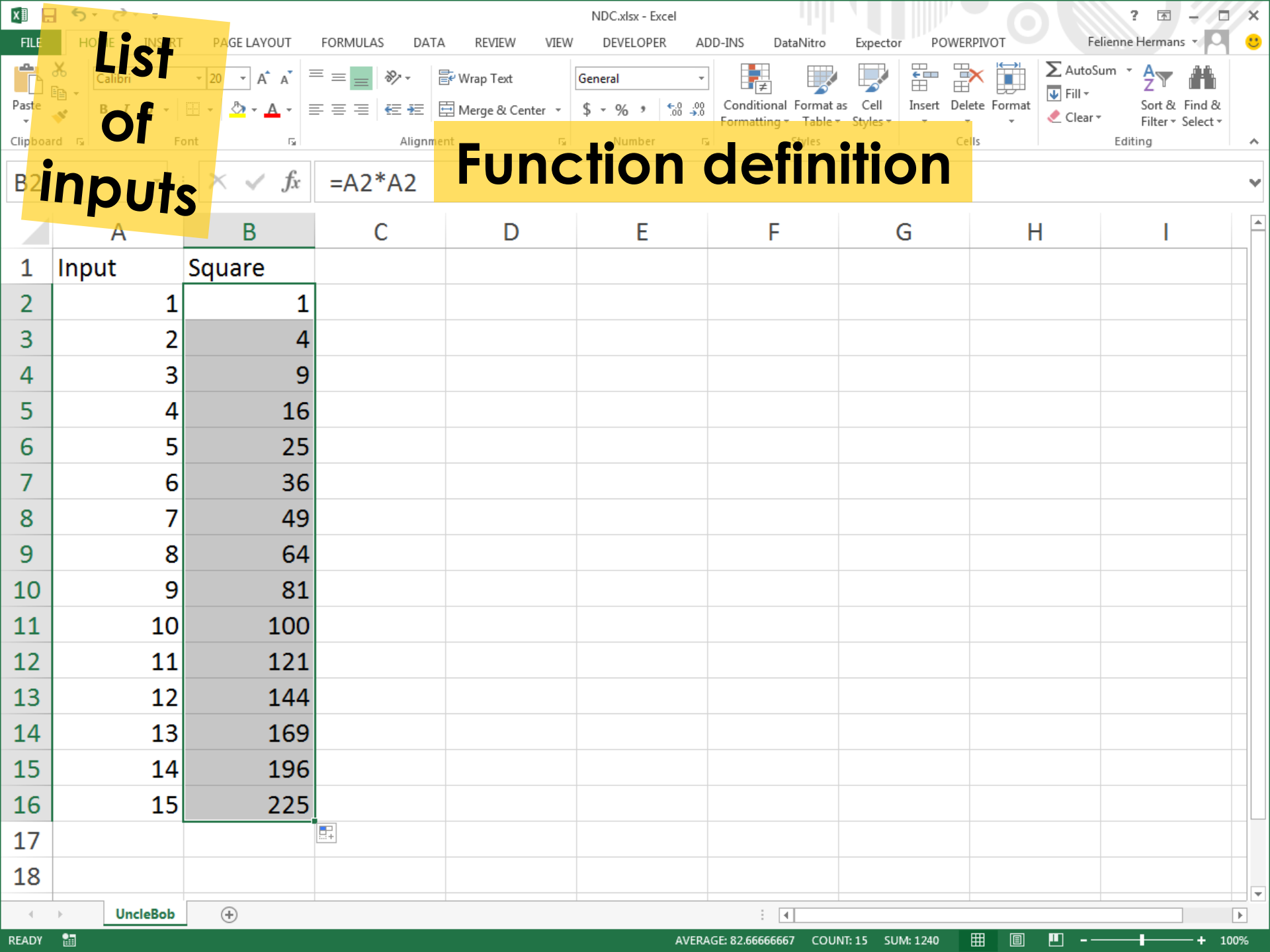
B2
=A2*A2
A
B
C
D
E
F
G
H
I
1 Input Square
2 1 1
3 2 4
4 3 9
5 4 16
6 5 25
7 6 36
8 7 49
9 8 64
10 9 81
11 10 100
12 11 121
13 12 144
14 13 169
15 14 196
16 15 225
17
18
UncleBob
READY
AVERAGE: 82.66666667
COUNT: 15
SUM: 1240
100%



Input	Square
1	1
2	4
3	9
4	16
5	25
6	36
7	49
8	64
9	81
10	100
11	121
12	144
13	169
14	196
15	225


NDC.xlsx - Excel
List of inputs
Function definition
=A2*A2
Input
Square
1 1
2 4
3 9
4 16
5 25
6 36
7 49
8 64
9 81
10 100
11 121
12 144
13 169
14 196
15 225
UncleBob
READY
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COUNT: 15
SUM: 1240
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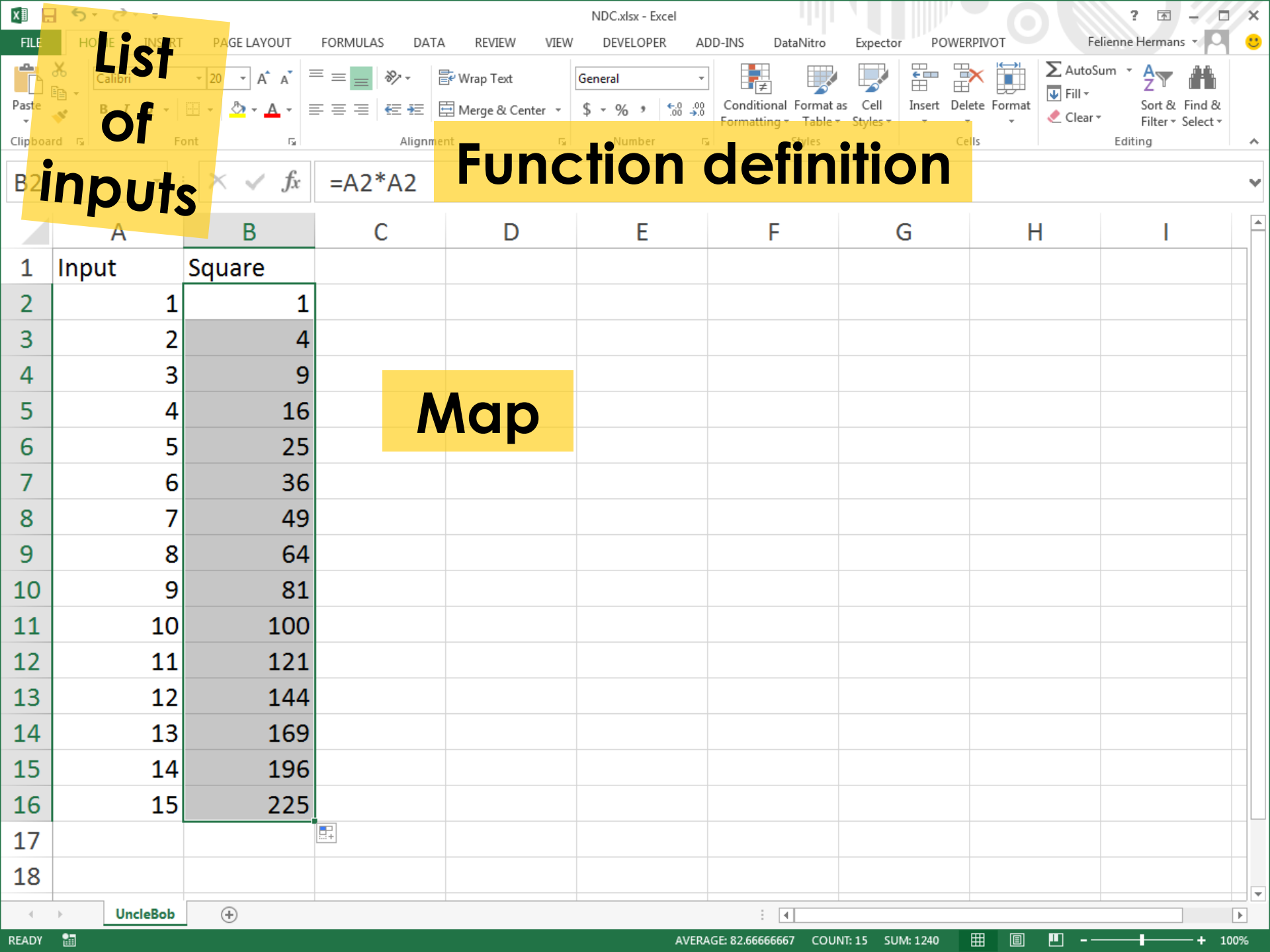
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Format as Table
Cell Styles
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Sort & Filter
Find & Select
Clipboard
Font
Alignment
Number
Styles
Cells
Editing
=A2*A2
List of inputs
Function definition
Map
Input
Square
1 1
2 4
3 9
4 16
5 25
6 36
7 49
8 64
9 81
10 100
11 121
12 144
13 169
14 196
15 225
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READY
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COUNT: 15
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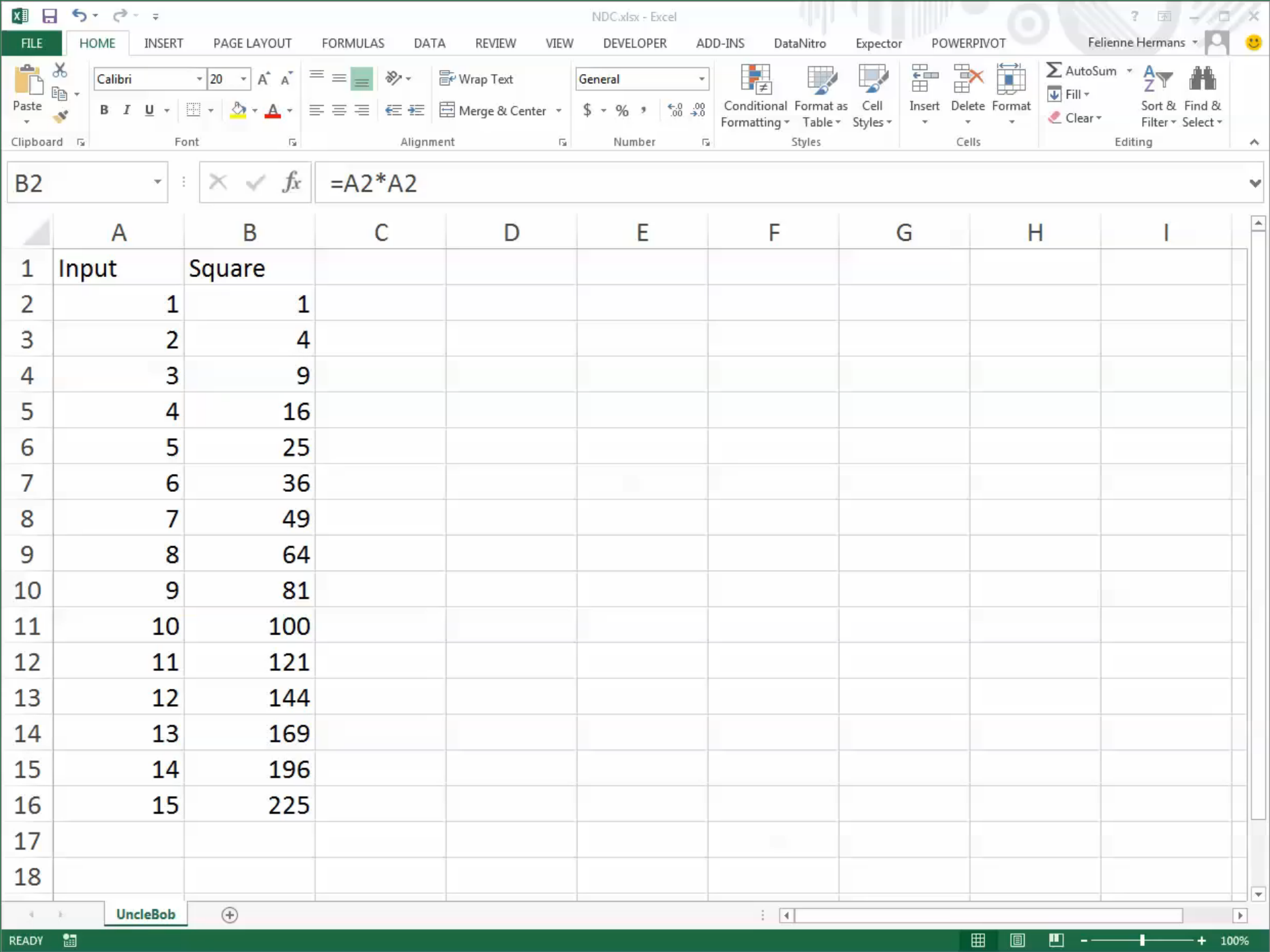
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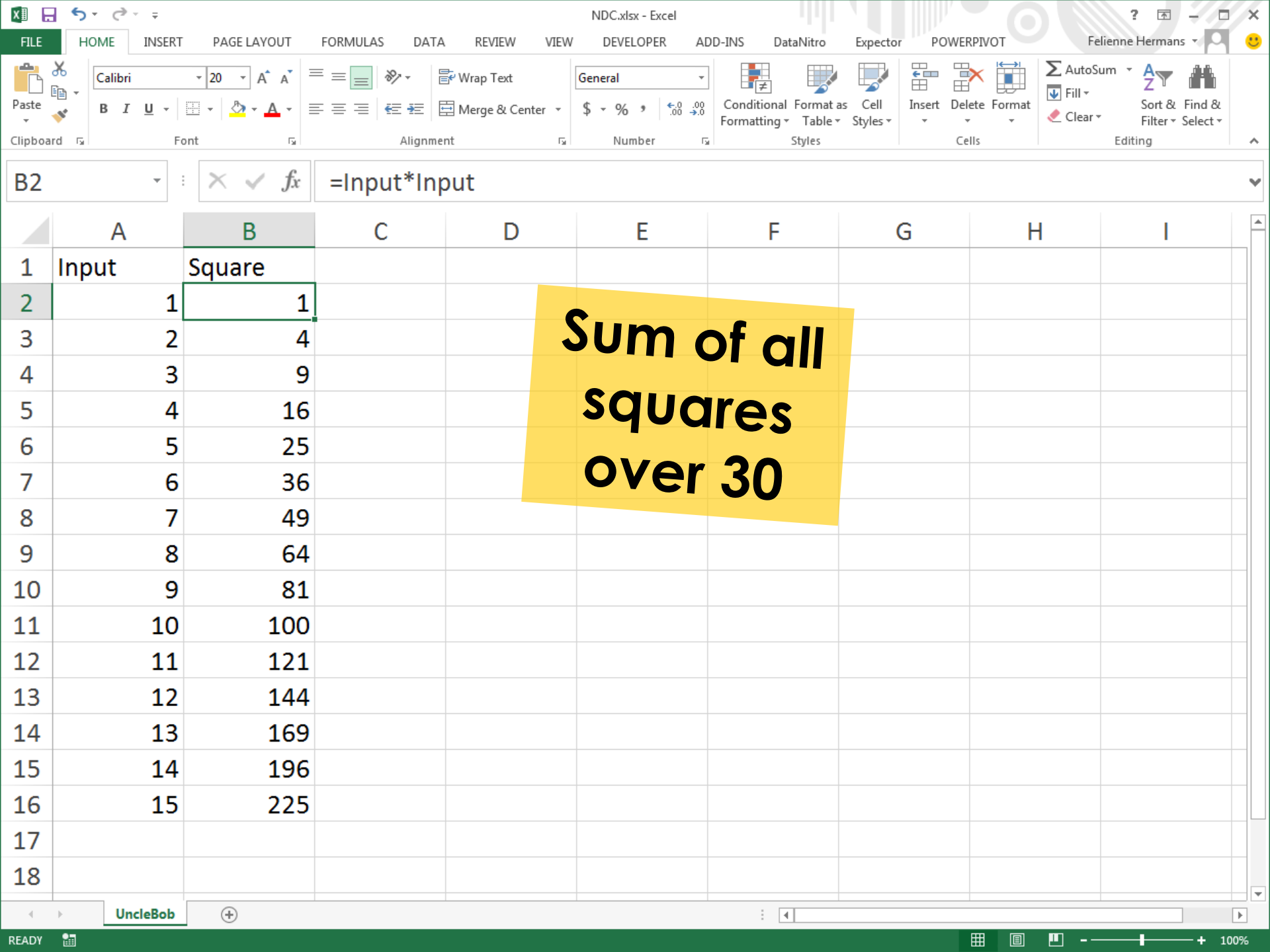
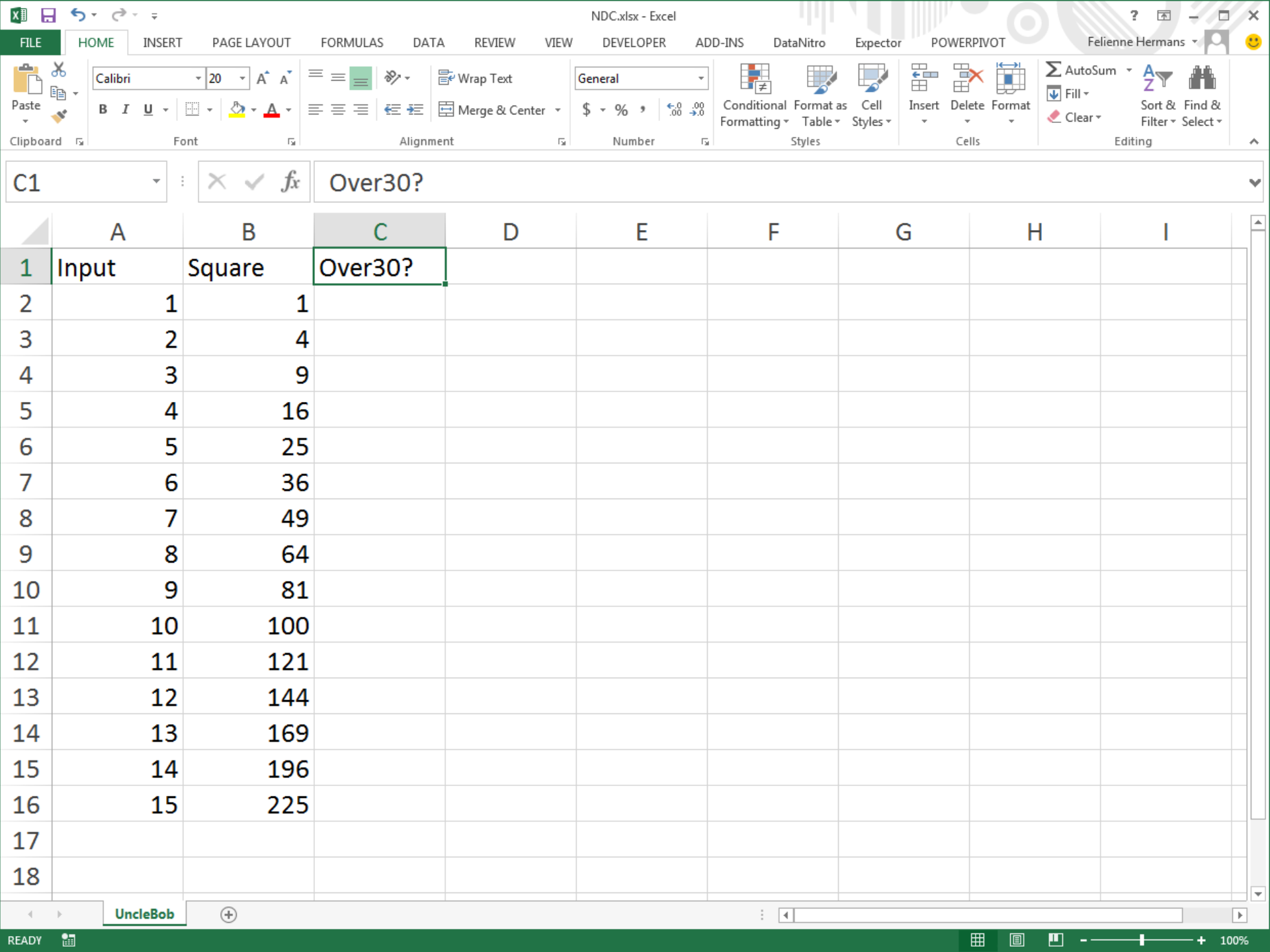
Editing
B2
=A2*A2
A
B
C
D
E
F
G
H
I
1 Input Square
2 1 1
3 2 4
4 3 9
5 4 16
6 5 25
7 6 36
8 7 49
9 8 64
10 9 81
11 10 100
12 11 121
13 12 144
14 13 169
15 14 196
16 15 225
17
18
UncleBob
READY
100%


A bit more exciting



	A	B
1	Input	Square
2	1	1
3	2	4
4	3	9
5	4	16
6	5	25
7	6	36
8	7	49
9	8	64
10	9	81
11	10	100
12	11	121
13	12	144
14	13	169
15	14	196
16	15	225
17		
18		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Wrap Text
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Conditional Formatting
Format as Table
Cell Styles
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AutoSum
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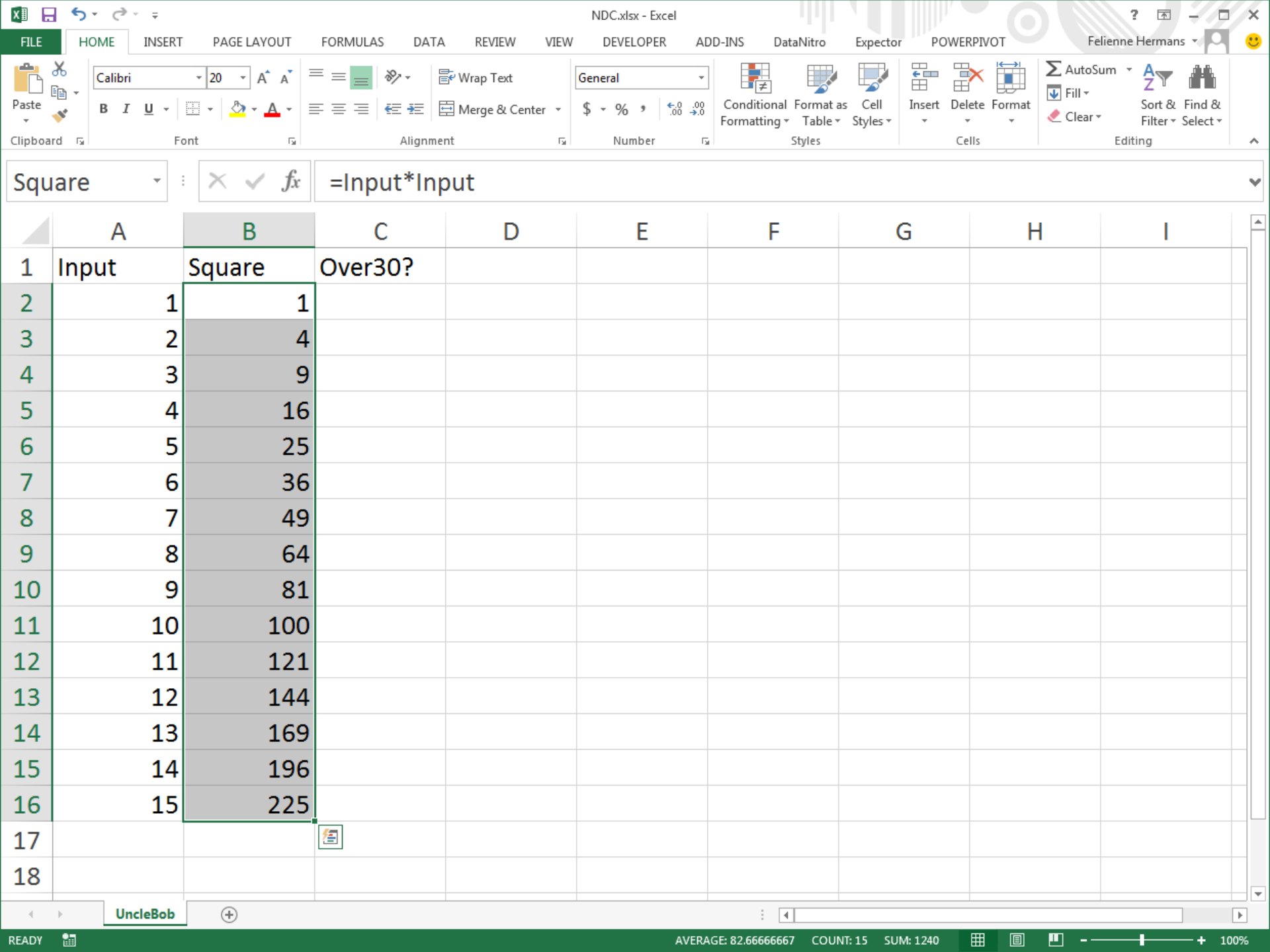
Sort & Filter
Find & Select
Clipboard
Font
Alignment
Number
Styles
Cells
Editing
C1
Over30?
A
B
C
D
E
F
G
H
I
1 Input Square Over30?
2 1 1
3 2 4
4 3 9
5 4 16
6 5 25
7 6 36
8 7 49
9 8 64
10 9 81
11 10 100
12 11 121
13 12 144
14 13 169
15 14 196
16 15 225
17
18
UncleBob
READY
100%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Editing
Square
=Input*Input
A
B
C
D
E
F
G
H
I
1 Input Square Over30?
2 1 1
3 2 4
4 3 9
5 4 16
6 5 25
7 6 36
8 7 49
9 8 64
10 9 81
11 10 100
12 11 121
13 12 144
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15 14 196
16 15 225
17
18
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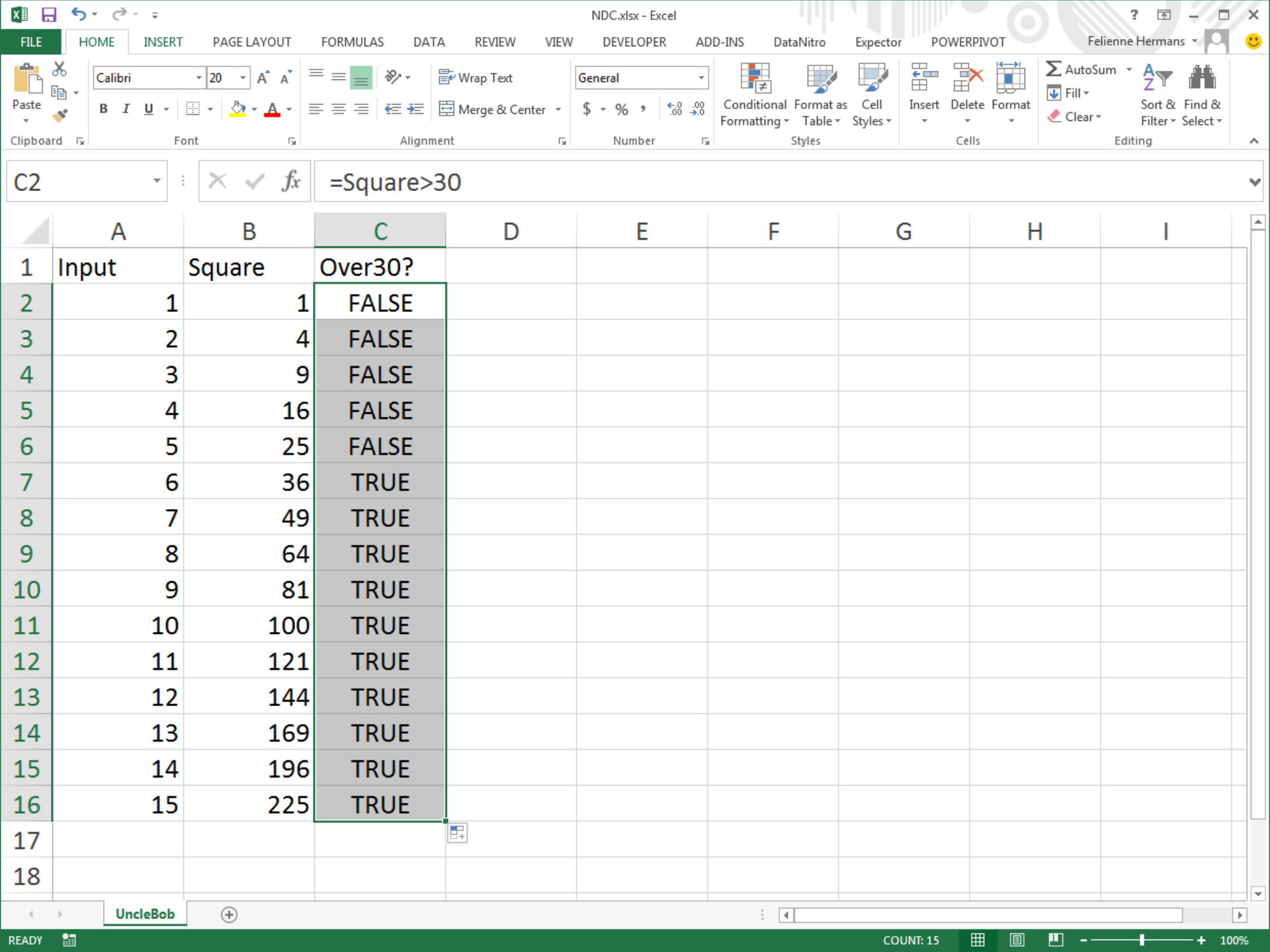
AVERAGE: 82.66666667
COUNT: 15
SUM: 1240
100%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Styles
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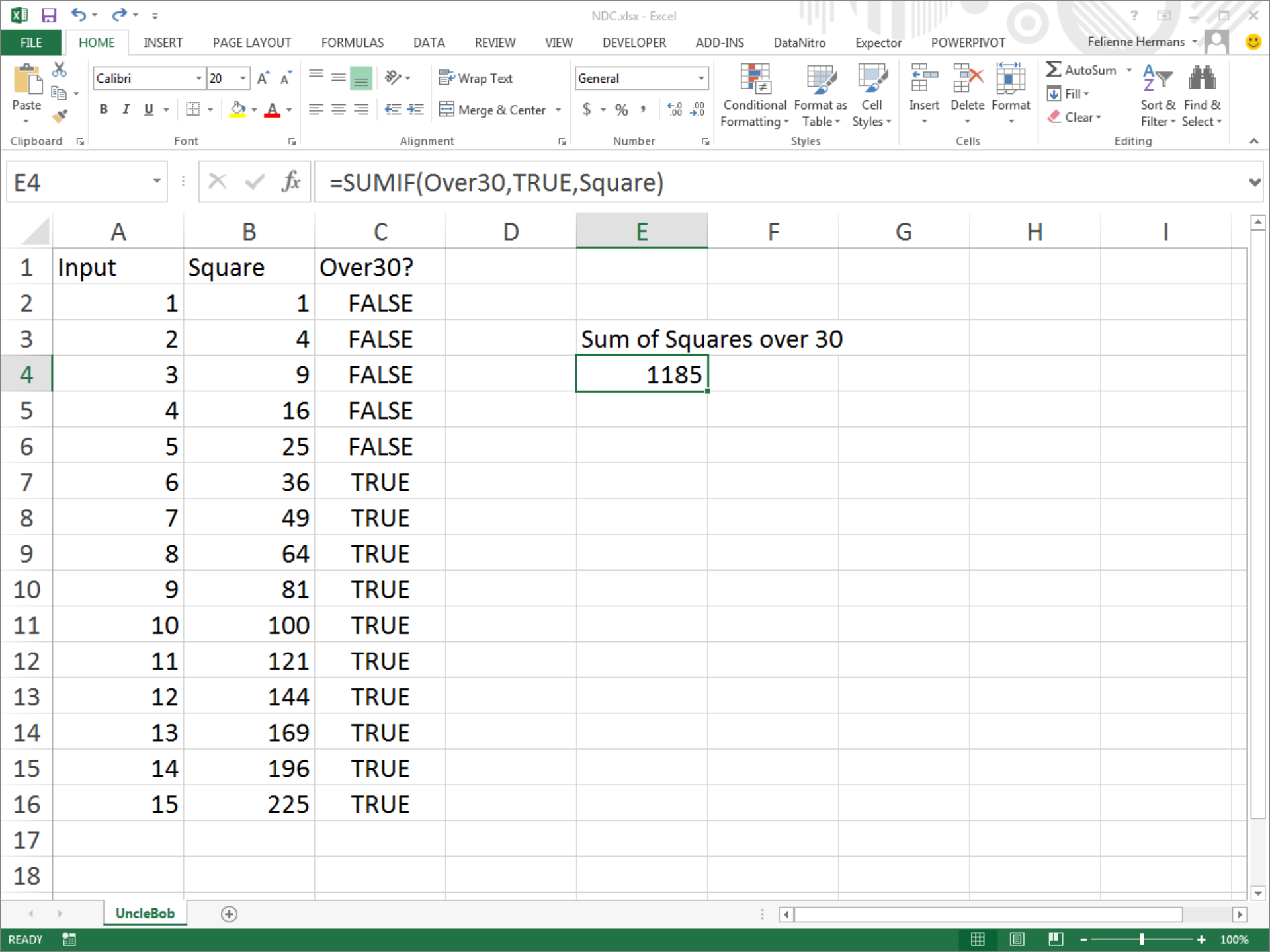
Editing
C2
=Square>30
A
B
C
D
E
F
G
H
I
1 Input Square Over30?
2 1 1 FALSE
3 2 4 FALSE
4 3 9 FALSE
5 4 16 FALSE
6 5 25 FALSE
7 6 36 TRUE
8 7 49 TRUE
9 8 64 TRUE
10 9 81 TRUE
11 10 100 TRUE
12 11 121 TRUE
13 12 144 TRUE
14 13 169 TRUE
15 14 196 TRUE
16 15 225 TRUE
17
18
UncleBob
READY
COUNT: 15
100%



	A	B	C	D	E	F	G	H	I
1	Input	Square	Over30?						
2	1	1	FALSE						
3	2	4	FALSE		Sum of Squares over 30				
4	3	9	FALSE		1185				
5	4	16	FALSE						
6	5	25	FALSE						
7	6	36	TRUE						
8	7	49	TRUE						
9	8	64	TRUE						
10	9	81	TRUE						
11	10	100	TRUE						
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14	13	169	TRUE						
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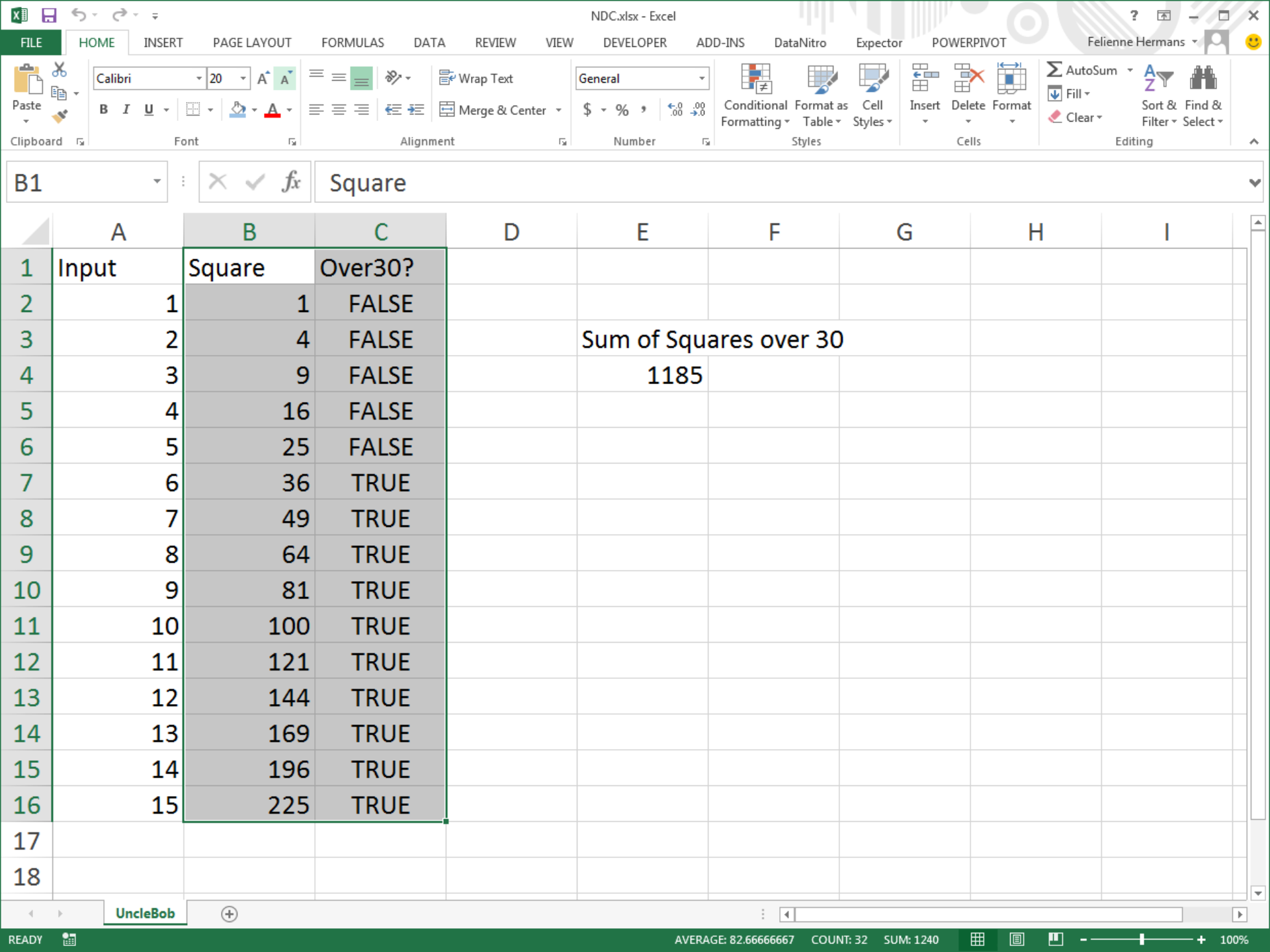
16	15	225	TRUE						
17									
18									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Find & Select
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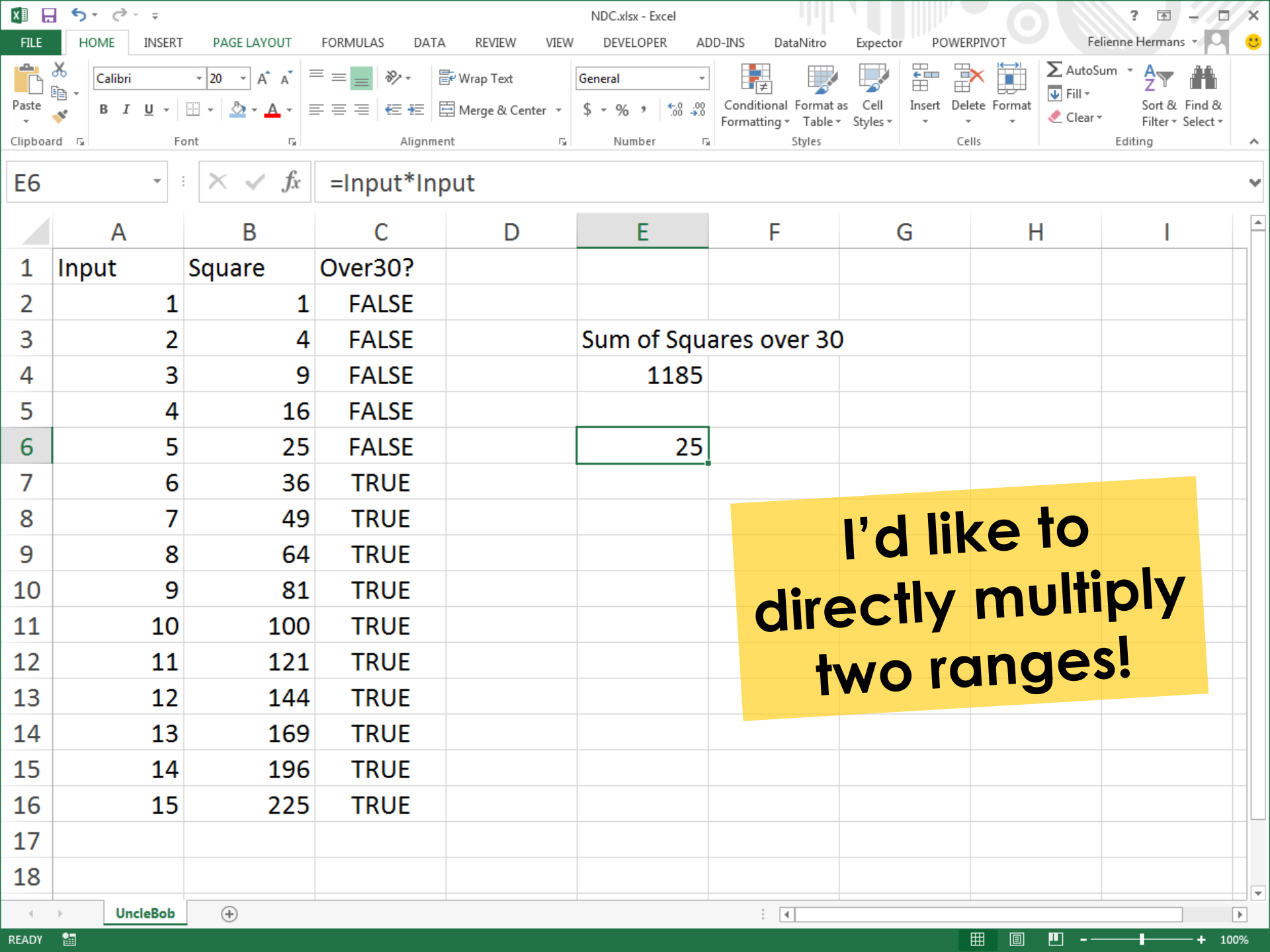
Alignment
Number
Styles
Cells
Editing
B1
Square
Input
Square
Over30?
1 1 FALSE
2 4 FALSE
3 9 FALSE
4 16 FALSE
5 25 FALSE
6 36 TRUE
7 49 TRUE
8 64 TRUE
9 81 TRUE
10 100 TRUE
11 121 TRUE
12 144 TRUE
13 169 TRUE
14 196 TRUE
15 225 TRUE
Sum of Squares over 30
1185
UncleBob
READY
AVERAGE: 82.66666667
COUNT: 32
SUM: 1240
100%



	A	B	C	D	E	F	G	H	I
1	Input	Square	Over30?						
2	1	1	FALSE						
3	2	4	FALSE		Sum of Squares over 30				
4	3	9	FALSE		1185				
5	4	16	FALSE						
6	5	25	FALSE		25				
7	6	36	TRUE						
8	7	49	TRUE						
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11	10	100	TRUE						
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14	13	169	TRUE						
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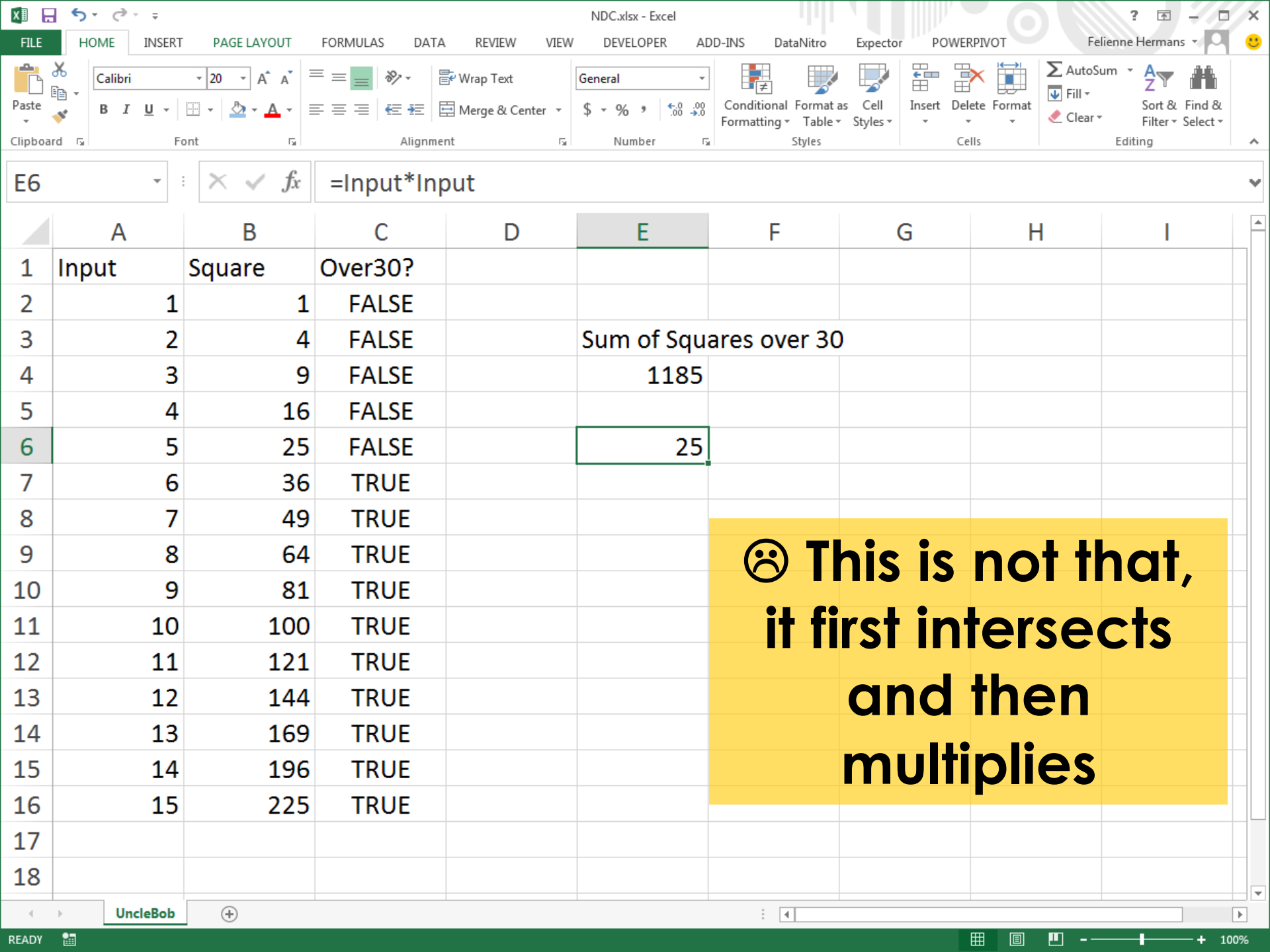
16	15	225	TRUE						
17									
18									



	A	B	C	D	E	F	G	H	I
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2	1	1	FALSE						
3	2	4	FALSE		Sum of Squares over 30				
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8	7	49	TRUE						
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10	9	81	TRUE						
11	10	100	TRUE						
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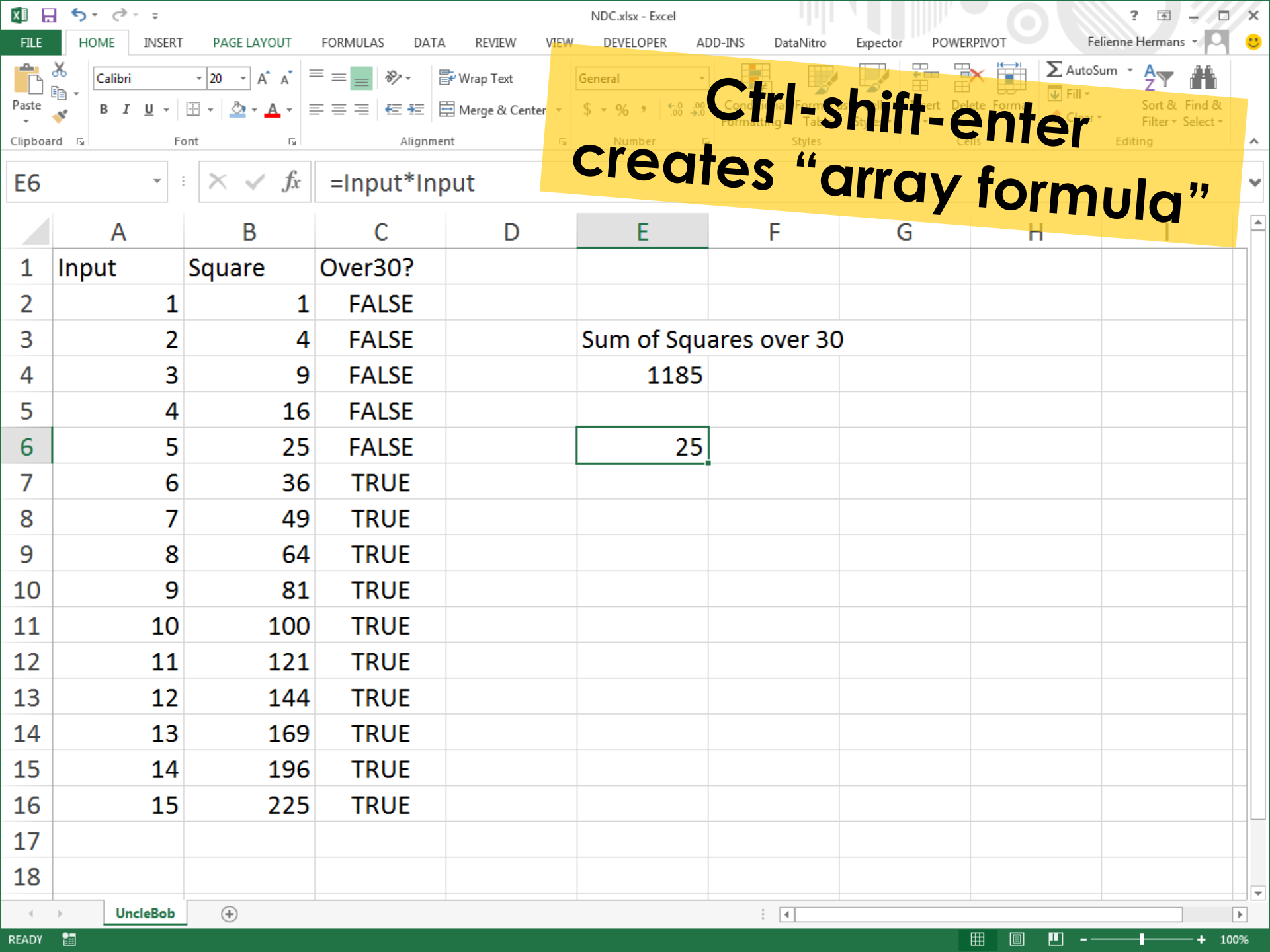

	A	B	C	D	E	F	G	H
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4	3	9	FALSE		1185			
5	4	16	FALSE					
6	5	25	FALSE		25			
7	6	36	TRUE					
8	7	49	TRUE					
9	8	64	TRUE					
10	9	81	TRUE					
11	10	100	TRUE					
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14	13	169	TRUE					
15	14	196	TRUE					
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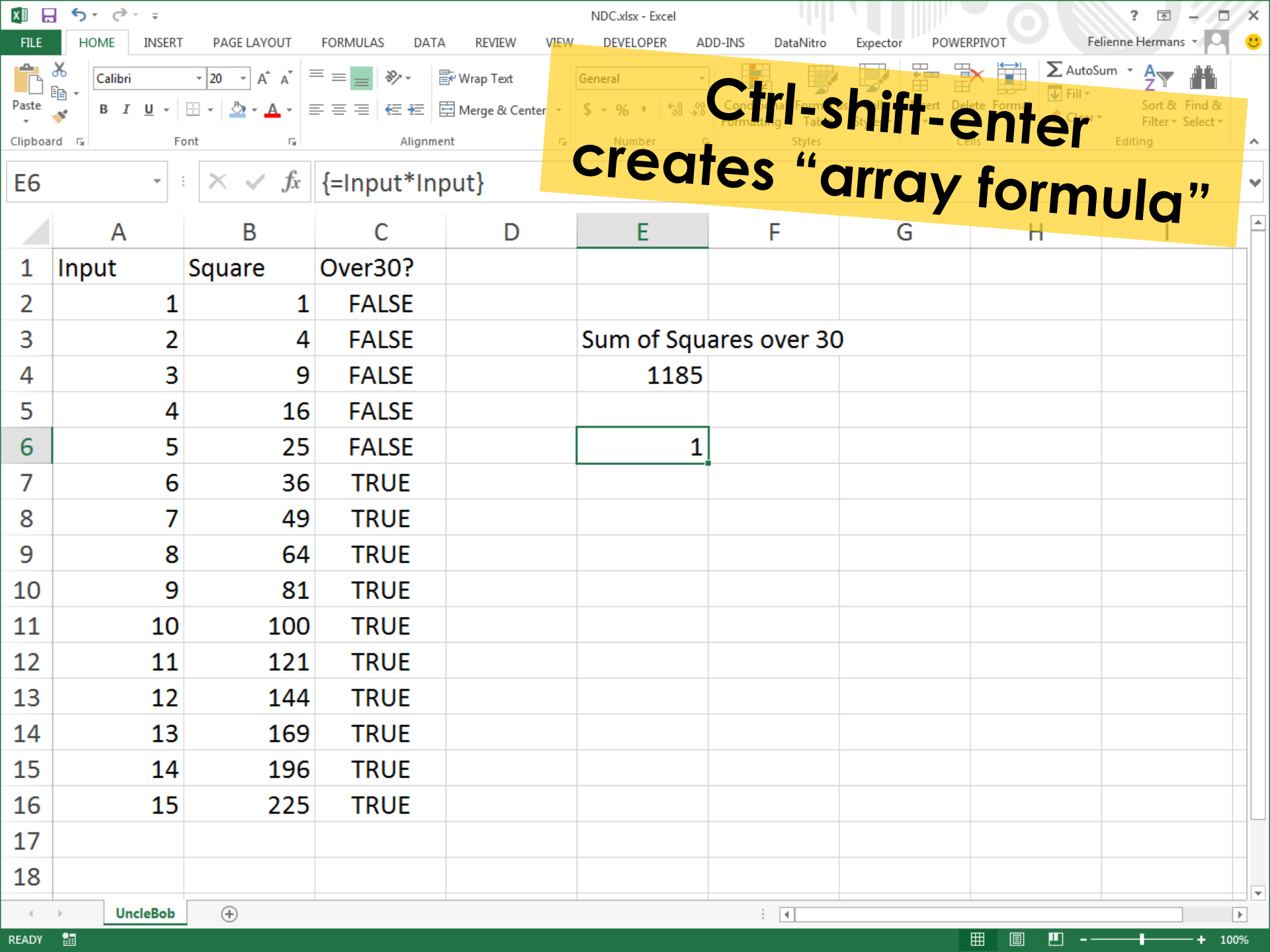

	A	B	C	D	E	F	G	H	I
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5	4	16	FALSE						
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7	6	36	TRUE						
8	7	49	TRUE						
9	8	64	TRUE						
10	9	81	TRUE						
11	10	100	TRUE						
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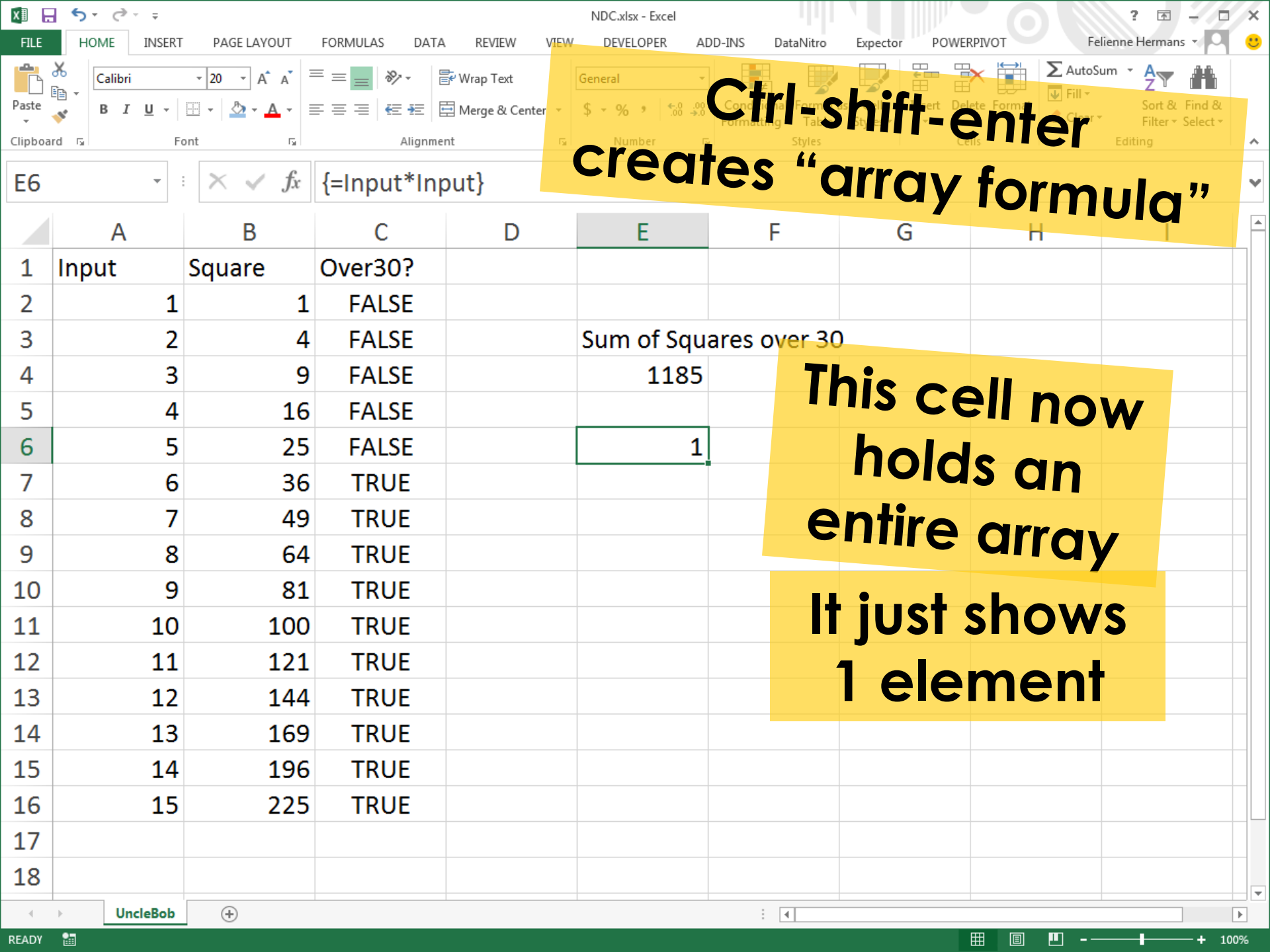

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3	2	4	FALSE		Sum of Squares over 30			
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5	4	16	FALSE					
6	5	25	FALSE		1			
7	6	36	TRUE					
8	7	49	TRUE					
9	8	64	TRUE					
10	9	81	TRUE					
11	10	100	TRUE					
12	11	121	TRUE					
13	12	144	TRUE					
14	13	169	TRUE					
15	14	196	TRUE					
16	15	225	TRUE					
17								
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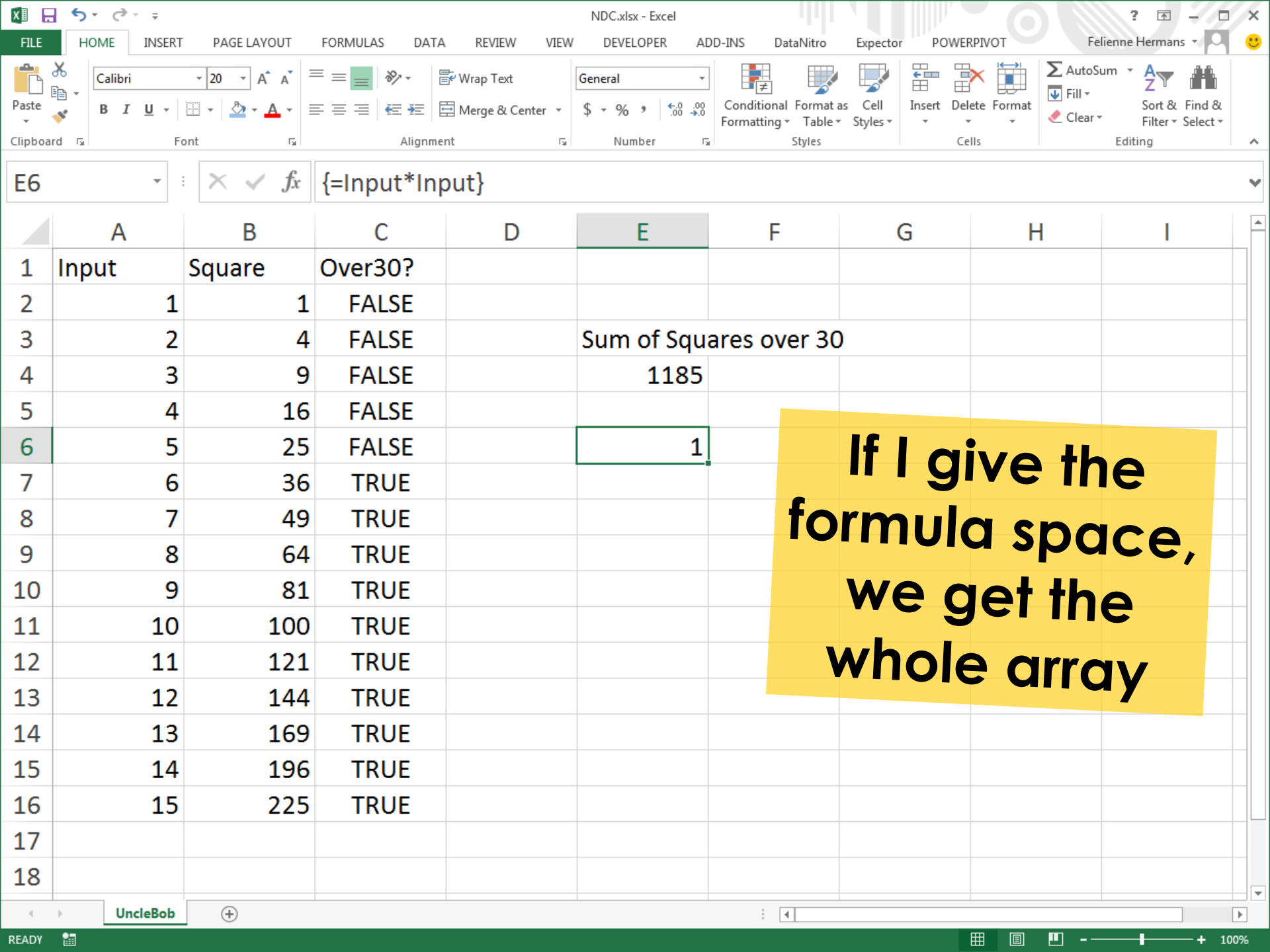

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11	10	100	TRUE						
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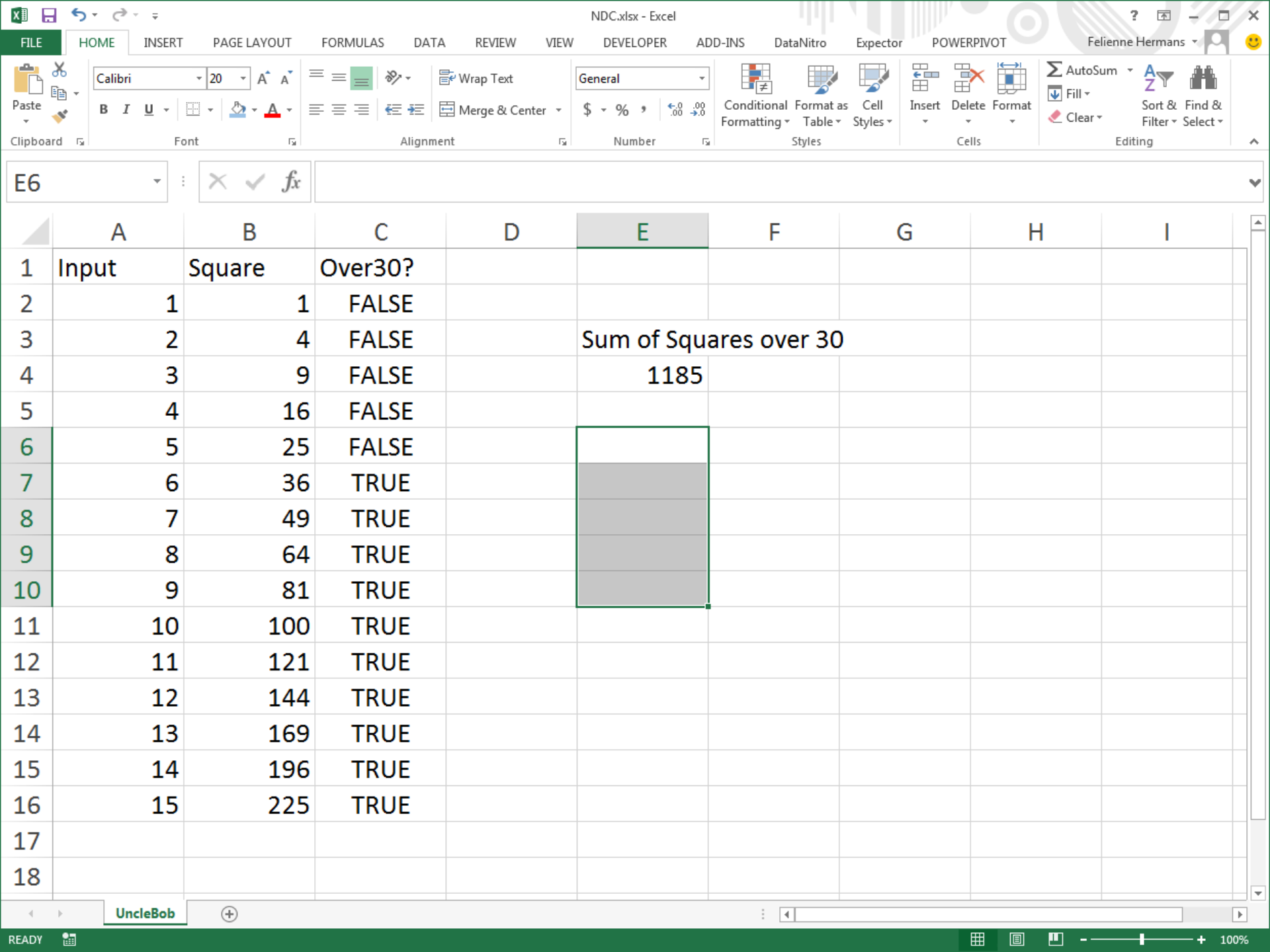
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Sort & Filter
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Clipboard
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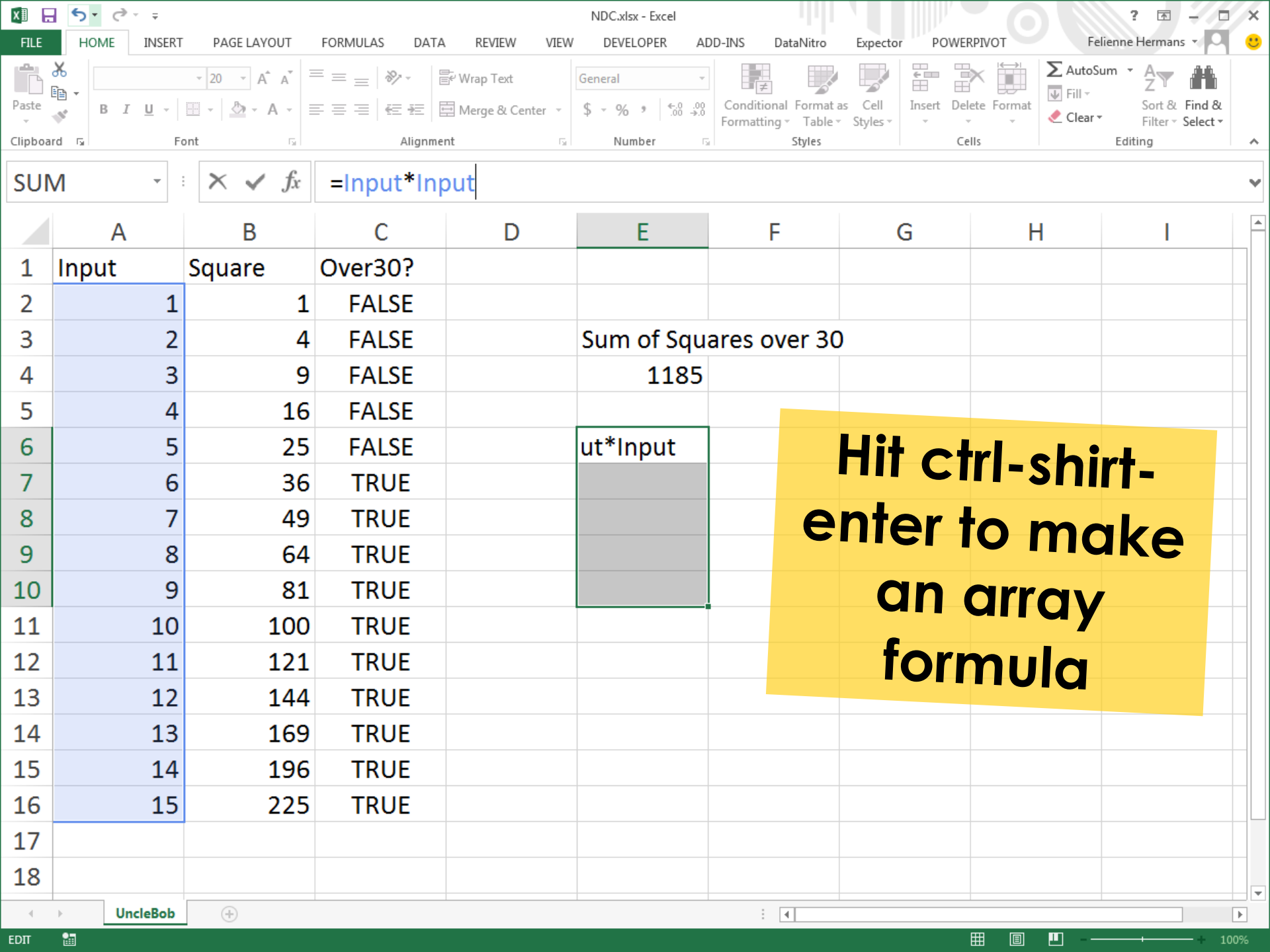
Editing
E6
Input
Square
Over30?
1 FALSE
2 FALSE
3 FALSE
4 FALSE
5 TRUE
6 TRUE
7 TRUE
8 TRUE
9 TRUE
10 TRUE
11 TRUE
12 TRUE
13 TRUE
14 TRUE
15 TRUE
Sum of Squares over 30
1185
UncleBob
READY
100%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Format as Table
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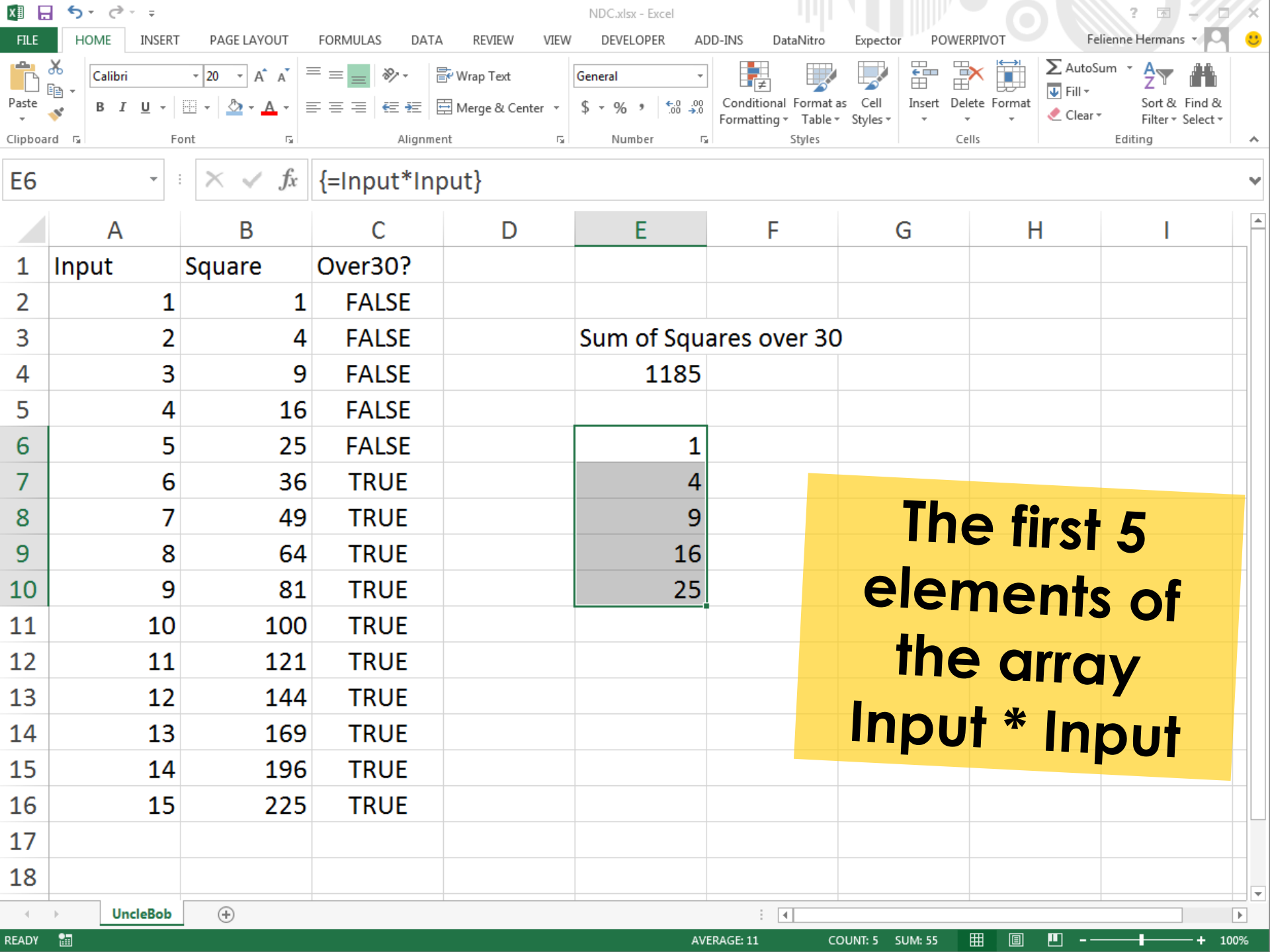
Sort & Filter
Find & Select
Editing
SUM
=Input*Input
Input
Square
Over30?
1 FALSE 1
2 FALSE 4
3 FALSE 9
4 FALSE 16
5 FALSE 25
6 TRUE 36
7 TRUE 49
8 TRUE 64
9 TRUE 81
10 TRUE 100
11 TRUE 121
12 TRUE 144
13 TRUE 169
14 TRUE 196
15 TRUE 225
Sum of Squares over 30
1185
ut*Input
Hit ctrl-shirt-enter to make an array formula
UncleBob
EDIT
100%



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11	10	100	TRUE						
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15	14	196	TRUE						
16	15	225	TRUE						
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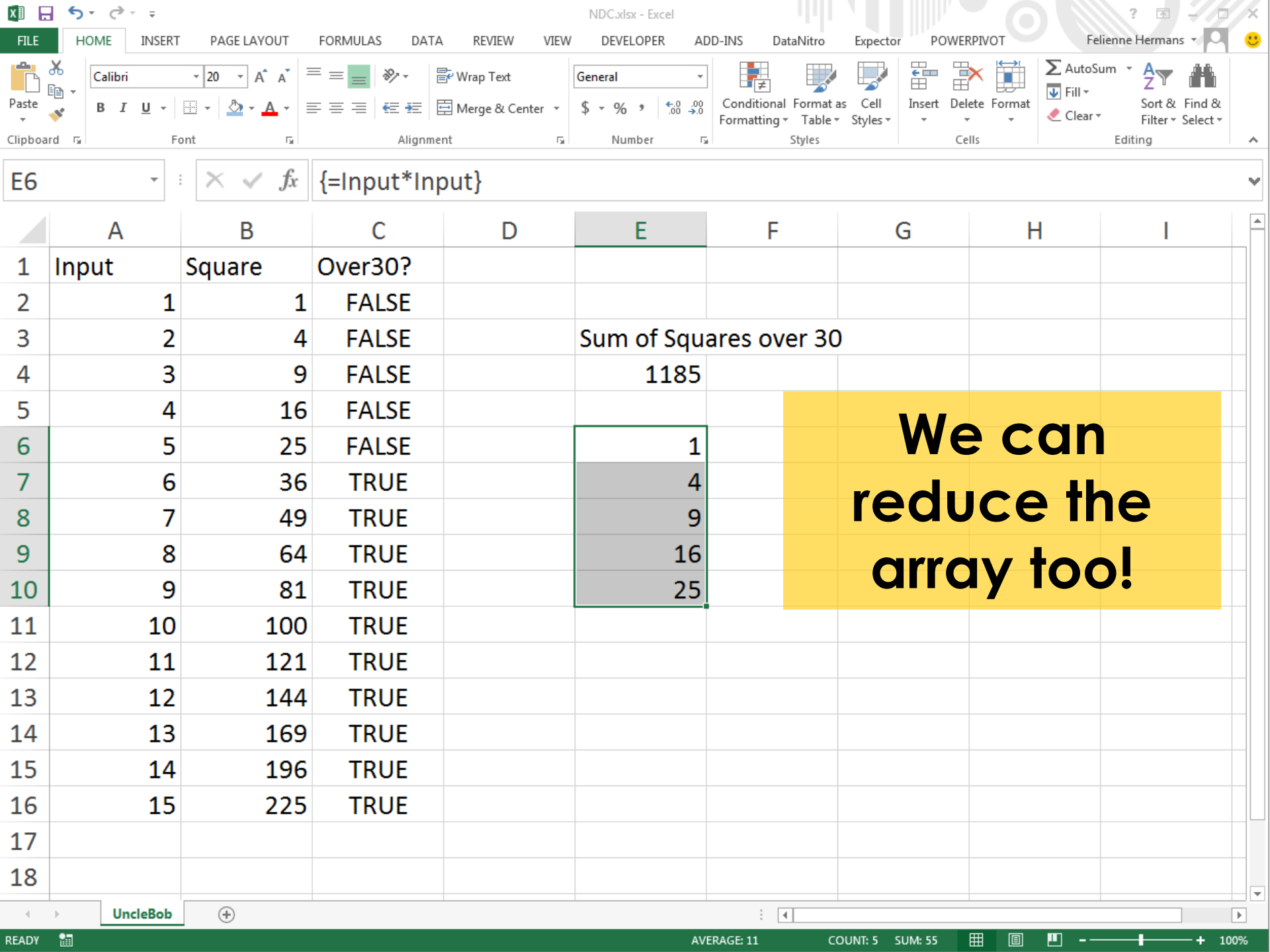

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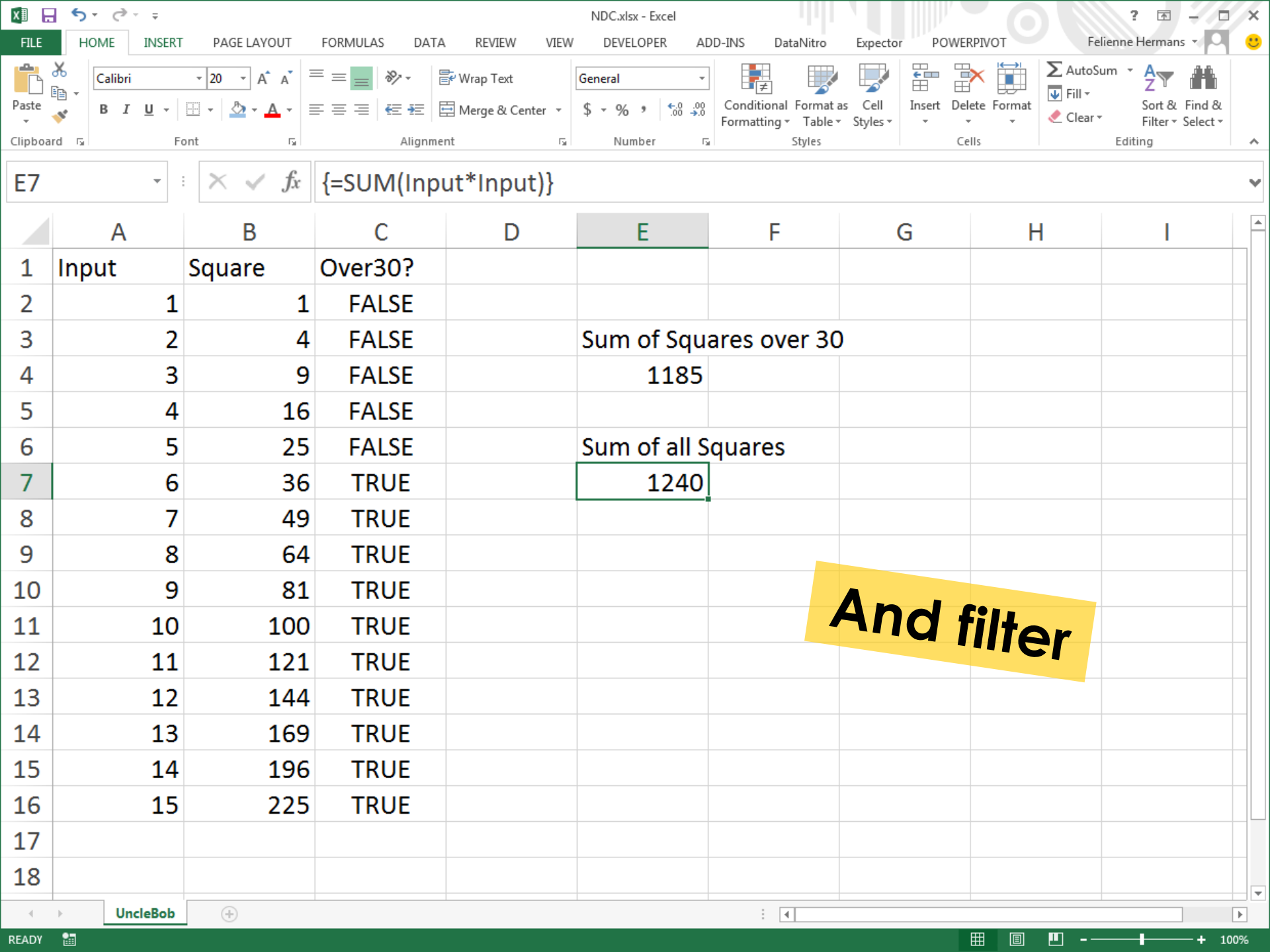
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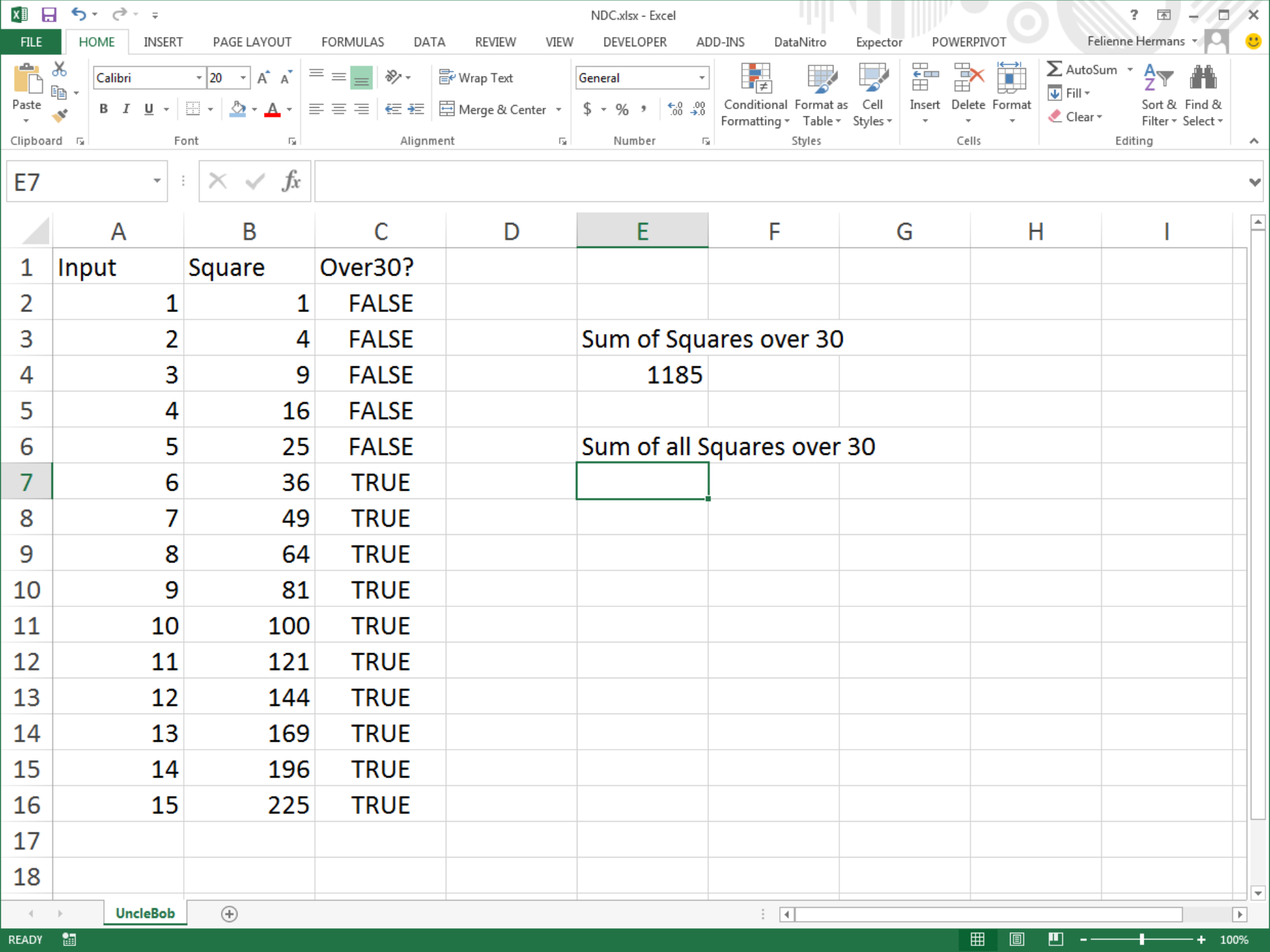
Styles
Cells
Editing
E7
{=SUM(Input*Input)}
Input
Square
Over30?
1 1 FALSE
2 4 FALSE
3 9 FALSE
4 16 FALSE
5 25 FALSE
6 36 TRUE
7 49 TRUE
8 64 TRUE
9 81 TRUE
10 100 TRUE
11 121 TRUE
12 144 TRUE
13 169 TRUE
14 196 TRUE
15 225 TRUE
Sum of Squares over 30
1185
Sum of all Squares
1240
And filter
UncleBob
READY
100%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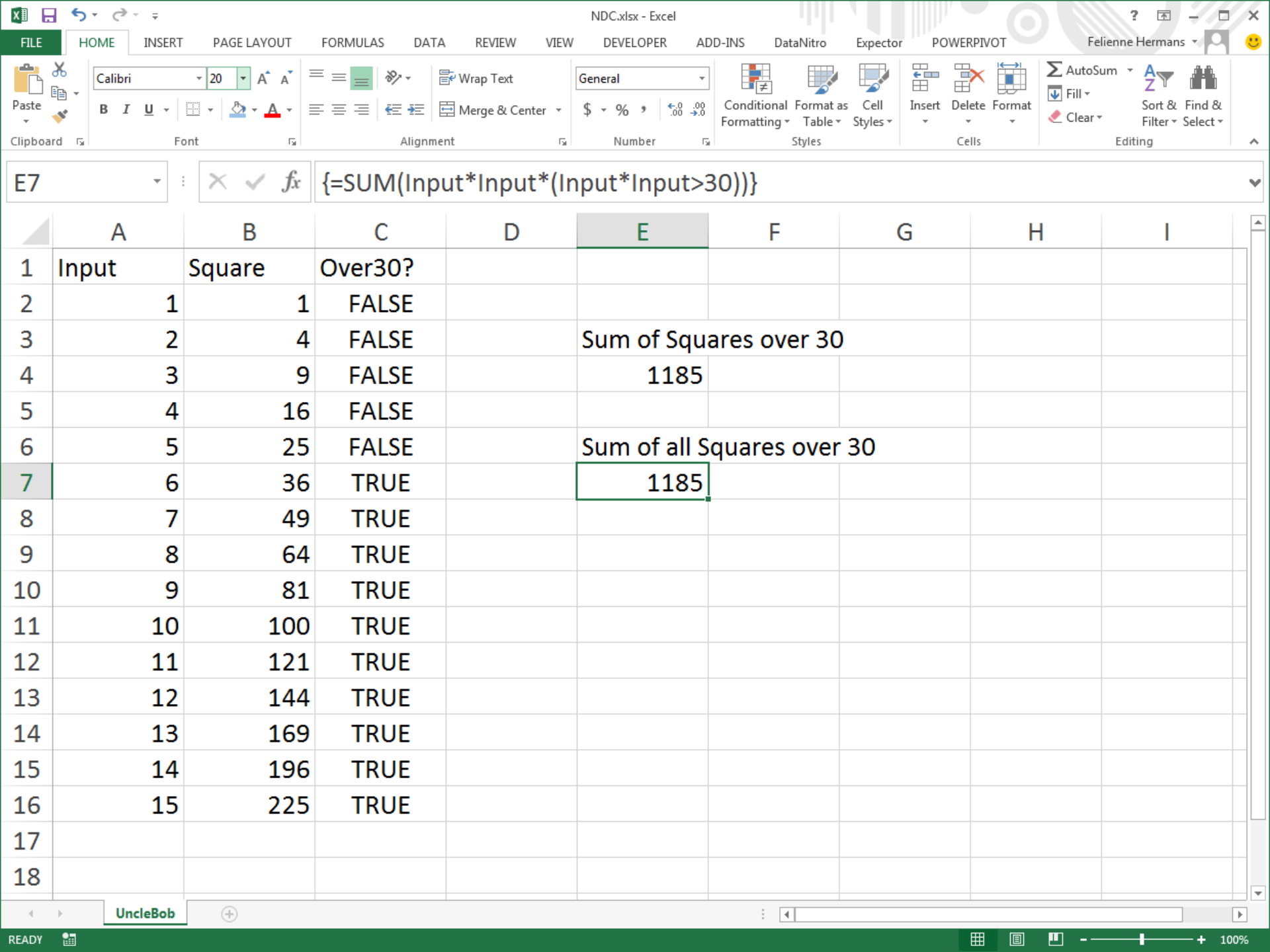
E7
Input
Square
Over30?
1 1 FALSE
2 4 FALSE
3 9 FALSE
4 16 FALSE
5 25 FALSE
6 36 TRUE
7 49 TRUE
8 64 TRUE
9 81 TRUE
10 100 TRUE
11 121 TRUE
12 144 TRUE
13 169 TRUE
14 196 TRUE
15 225 TRUE
Sum of Squares over 30
1185
Sum of all Squares over 30
UncleBob
READY
100%



	A	B	C	D	E	F	G	H	I
1	Input	Square	Over30?						
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3	2	4	FALSE		Sum of Squares over 30				
4	3	9	FALSE		1185				
5	4	16	FALSE						
6	5	25	FALSE		Sum of all Squares over 30				
7	6	36	TRUE		1185				
8	7	49	TRUE						
9	8	64	TRUE						
10	9	81	TRUE						
11	10	100	TRUE						
12	11	121	TRUE						
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14	13	169	TRUE						
15	14	196	TRUE						
16	15	225	TRUE						
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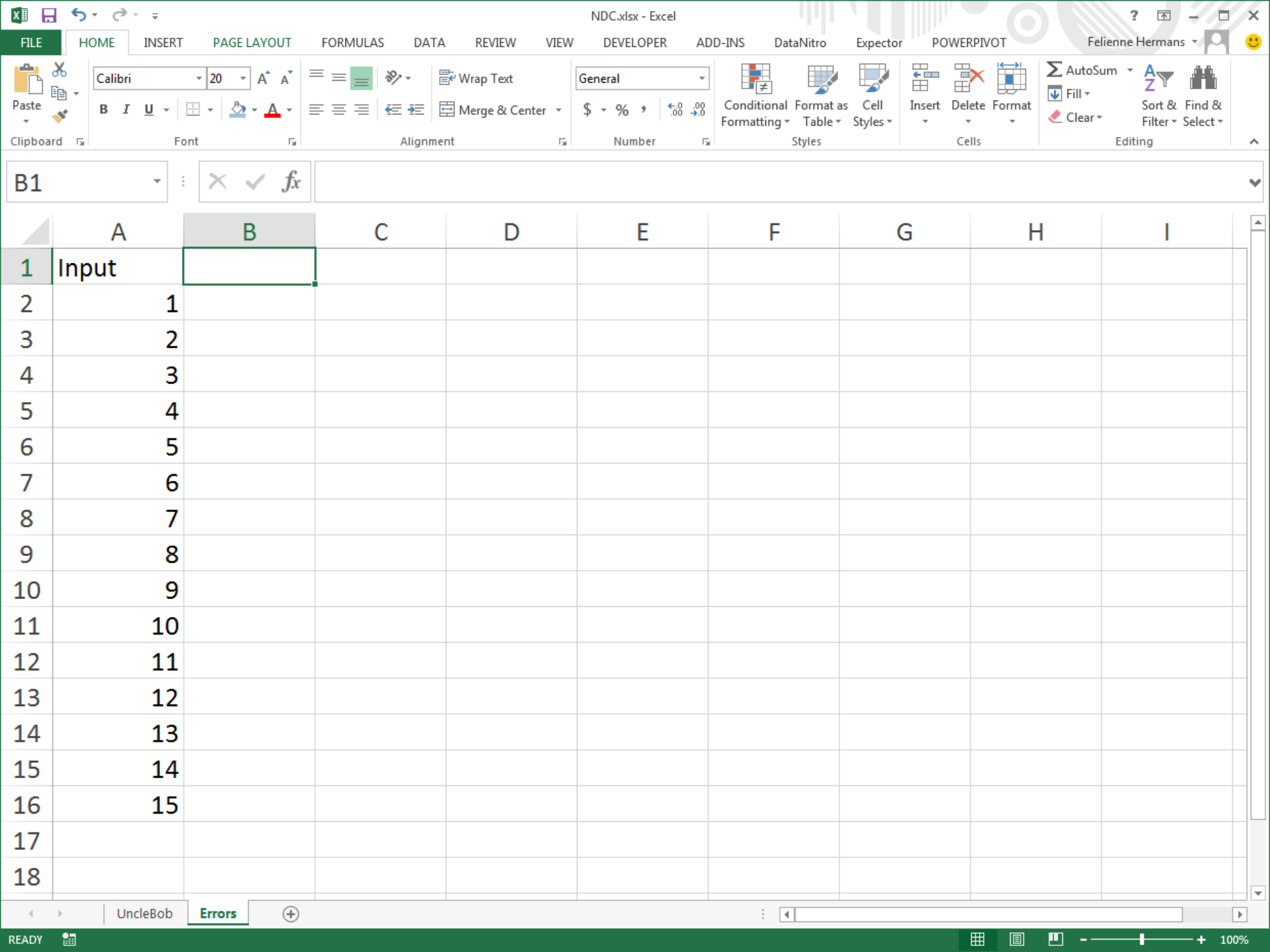
18									


ERROR
1
6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Fill
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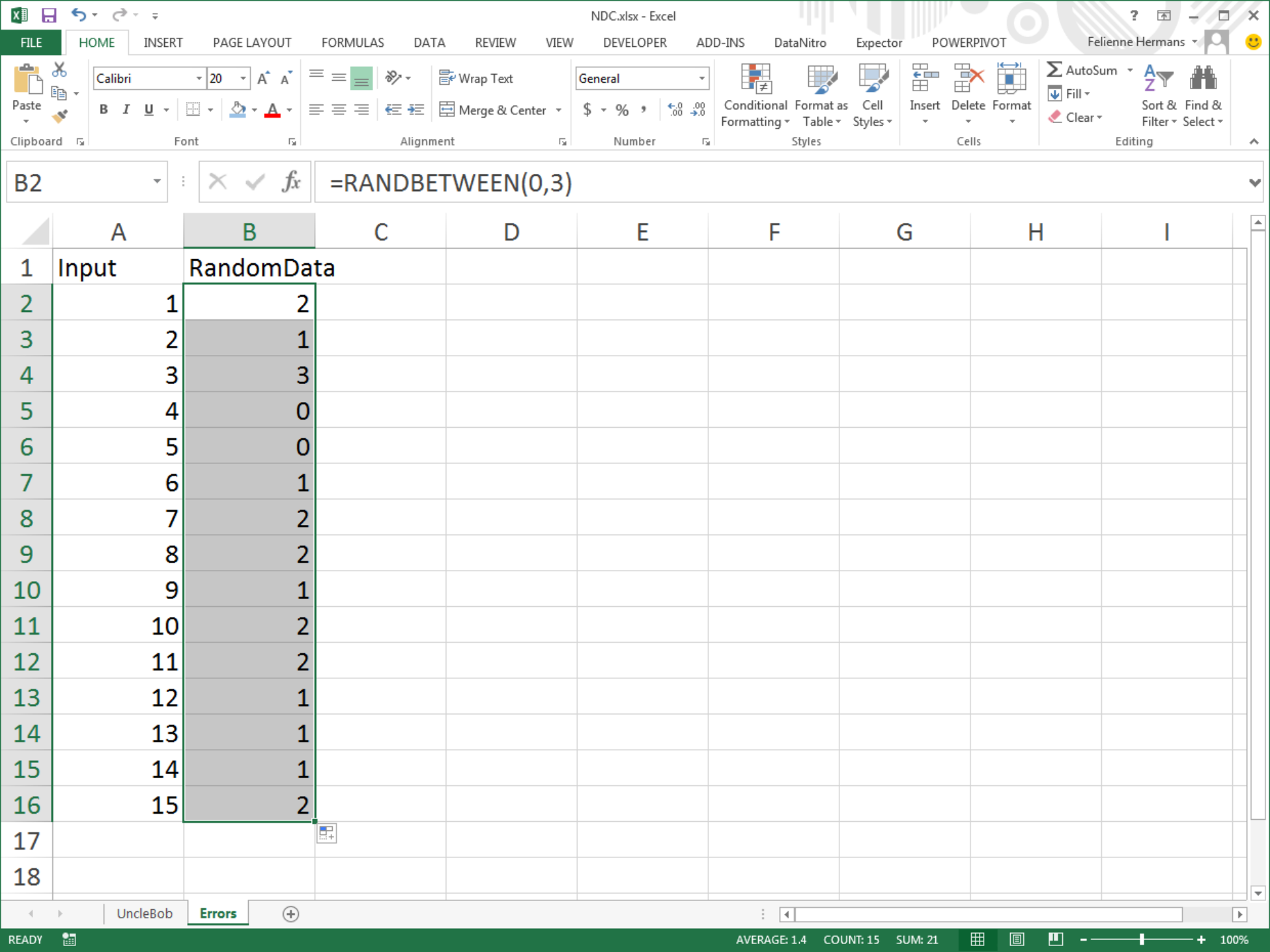
Find & Select
Clipboard
Font
Alignment
Number
Styles
Cells
Editing
B1
A
B
C
D
E
F
G
H
I
1 Input
2 1
3 2
4 3
5 4
6 5
7 6
8 7
9 8
10 9
11 10
12 11
13 12
14 13
15 14
16 15
17
18
UncleBob
Errors
READY
100%


NDC.xlsx - Excel
FILE
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PAGE LAYOUT
FORMULAS
DATA
REVIEW
VIEW
DEVELOPER
ADD-INS
DataNitro
Expector
POWERPIVOT
Felienne Hermans
Paste
Calibri
20
Wrap Text
General
Merge & Center
Conditional Formatting
Format as Table
Cell Styles
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AutoSum
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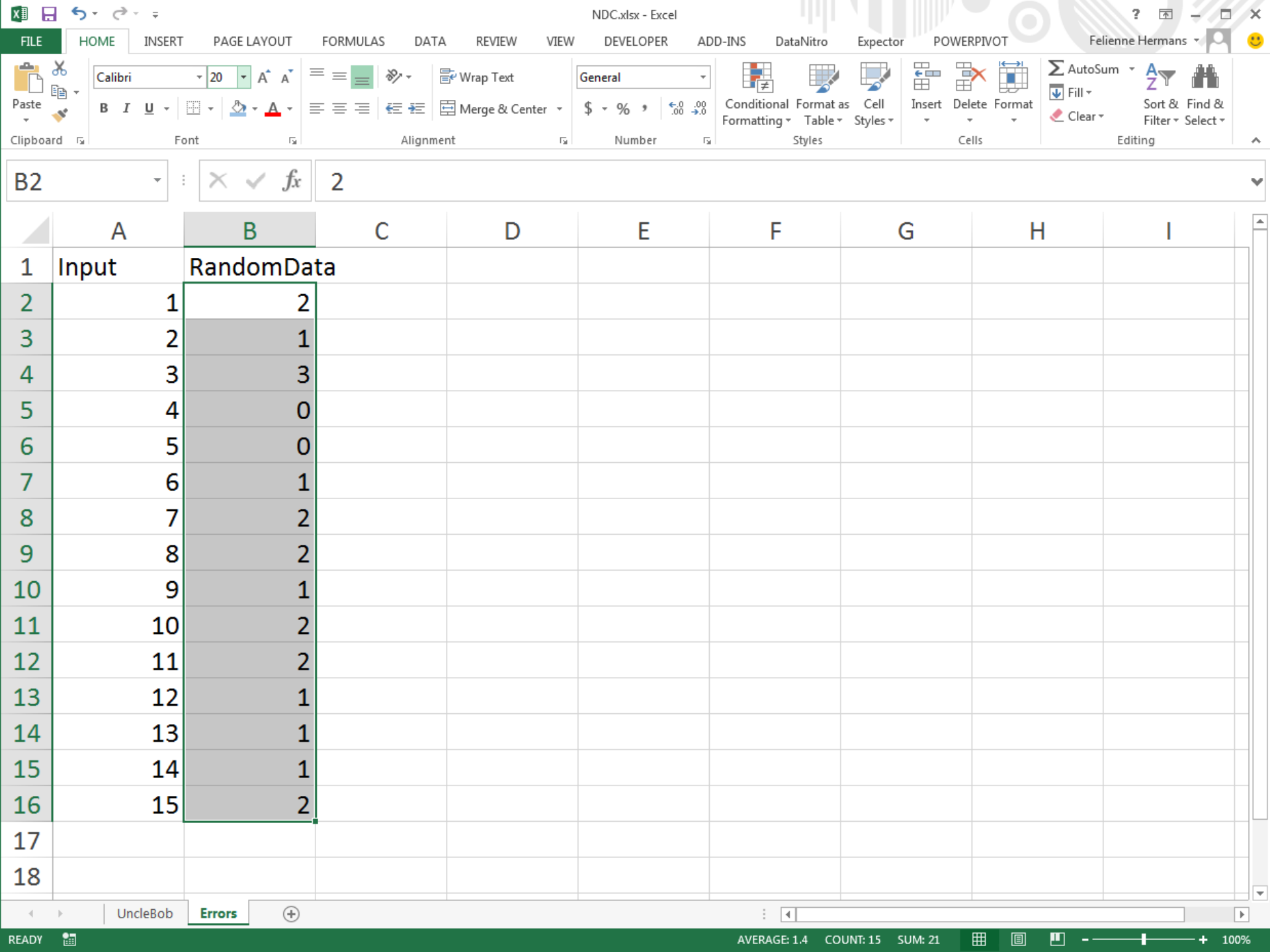
Clear
Sort & Filter
Find & Select
Clipboard
Font
Alignment
Number
Styles
Cells
Editing
B2
=RANDBETWEEN(0,3)
A
B
C
D
E
F
G
H
I
1 Input RandomData
2 1 2
3 2 1
4 3 3
5 4 0
6 5 0
7 6 1
8 7 2
9 8 2
10 9 1
11 10 2
12 11 2
13 12 1
14 13 1
15 14 1
16 15 2
17
18
UncleBob
Errors
READY
AVERAGE: 1.4
COUNT: 15
SUM: 21
100%


NDC.xlsx - Excel
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Wrap Text
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Merge & Center
Conditional Formatting
Format as Table
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Styles
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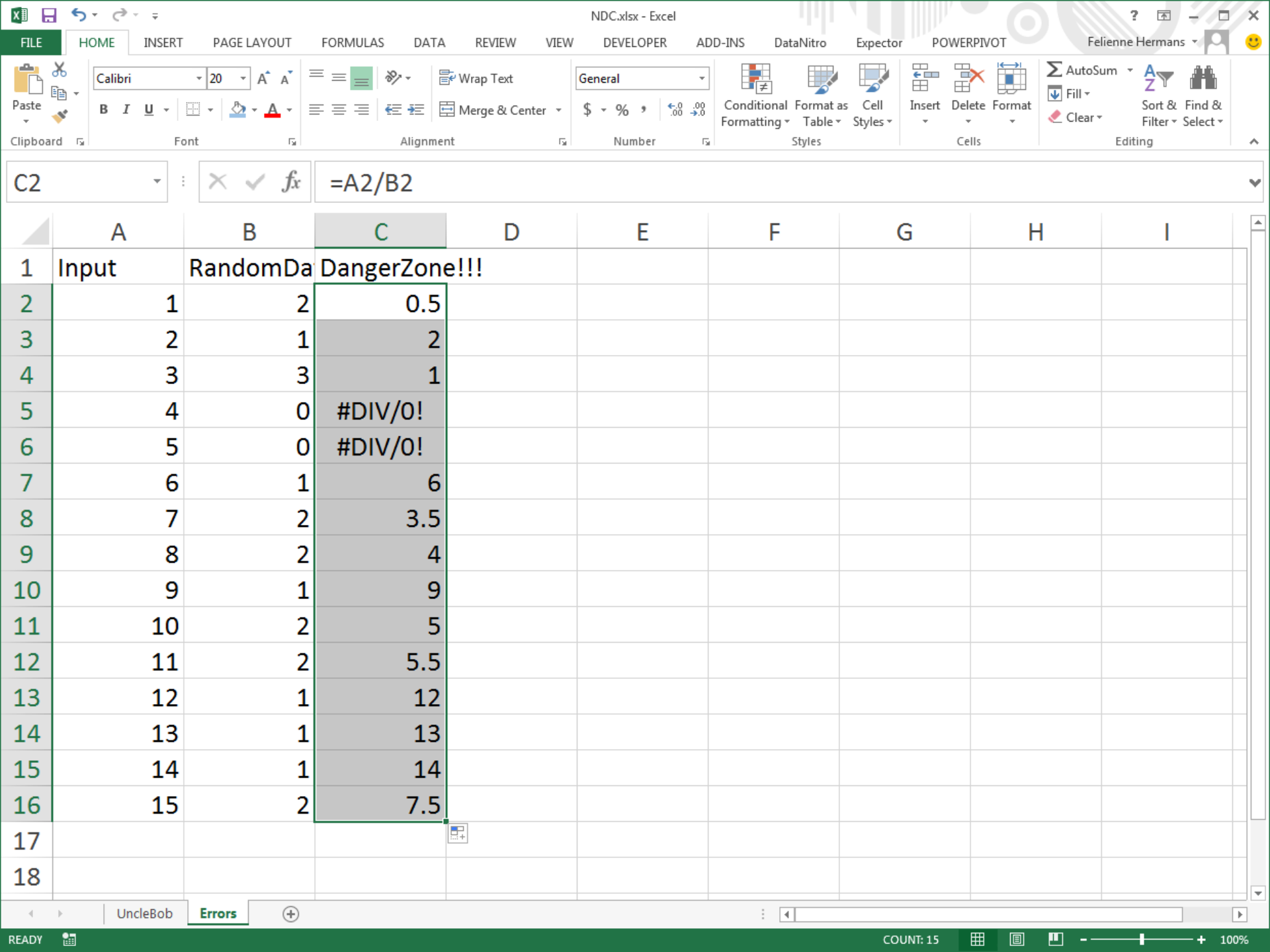
Editing
B2
2
A
B
C
D
E
F
G
H
I
1 Input RandomData
2 1 2
3 2 1
4 3 3
5 4 0
6 5 0
7 6 1
8 7 2
9 8 2
10 9 1
11 10 2
12 11 2
13 12 1
14 13 1
15 14 1
16 15 2
17
18
UncleBob
Errors
READY
AVERAGE: 1.4
COUNT: 15
SUM: 21
100%


NDC.xlsx - Excel
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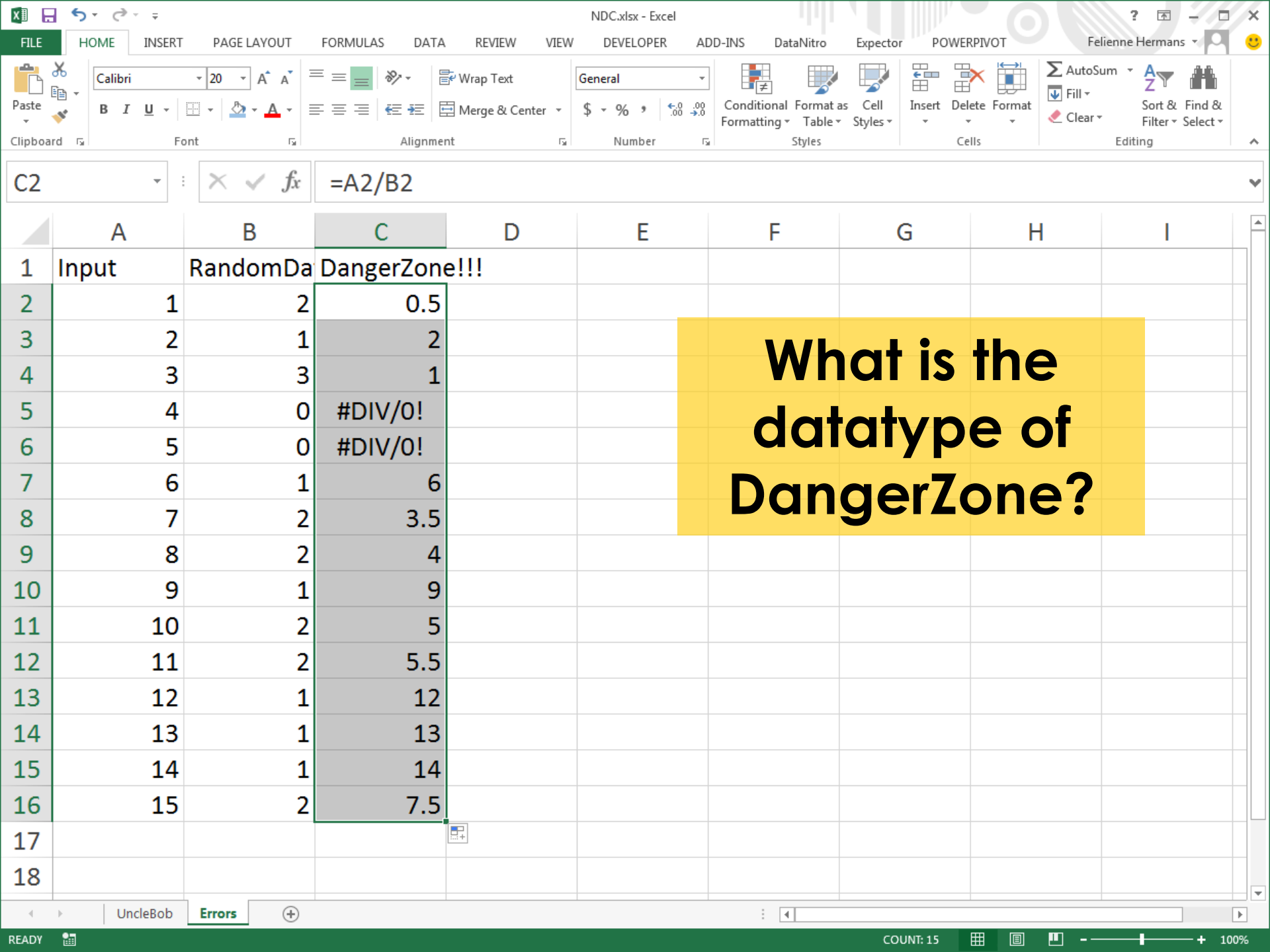
Conditional Formatting
Format as Table
Cell Styles
Insert
Delete
Format
AutoSum
Fill
Clear
Sort & Filter
Find & Select
Clipboard
Font
Alignment
Number
Styles
Cells
Editing
C2
=A2/B2
A
B
C
D
E
F
G
H
I
1 Input RandomDa DangerZone!!!
2 1 2 0.5
3 2 1 2
4 3 3 1
5 4 0 #DIV/0!
6 5 0 #DIV/0!
7 6 1 6
8 7 2 3.5
9 8 2 4
10 9 1 9
11 10 2 5
12 11 2 5.5
13 12 1 12
14 13 1 13
15 14 1 14
16 15 2 7.5
17
18
UncleBob
Errors
READY
COUNT: 15
100%


NDC.xlsx - Excel
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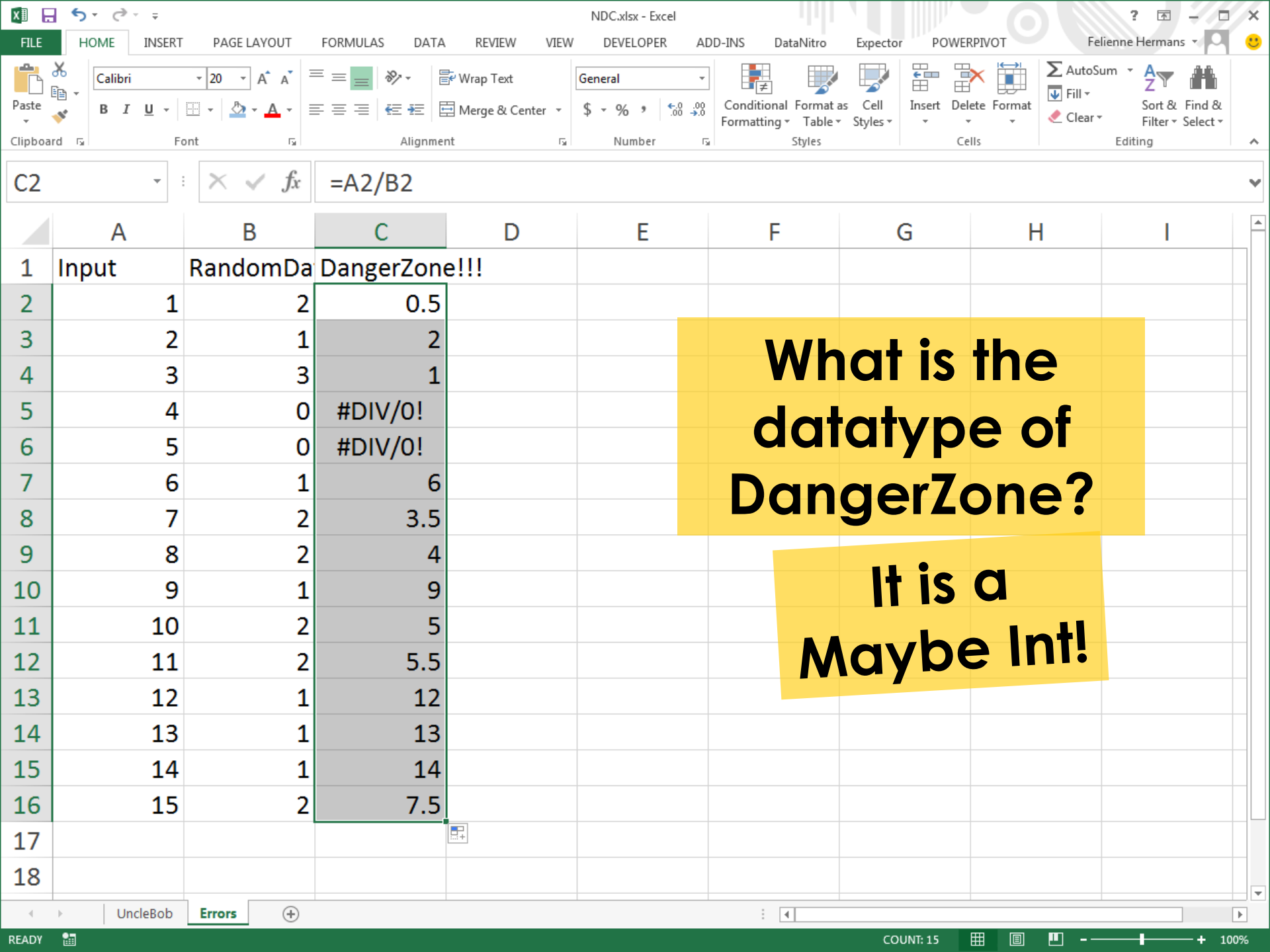
Format
AutoSum
Fill
Clear
Sort & Filter
Find & Select
Clipboard
Font
Alignment
Number
Styles
Cells
Editing
C2
=A2/B2
A
B
C
D
E
F
G
H
I
1 Input RandomDa DangerZone!!!
2 1 2 0.5
3 2 1 2
4 3 3 1
5 4 0 #DIV/0!
6 5 0 #DIV/0!
7 6 1 6
8 7 2 3.5
9 8 2 4
10 9 1 9
11 10 2 5
12 11 2 5.5
13 12 1 12
14 13 1 13
15 14 1 14
16 15 2 7.5
17
18
What is the datatype of DangerZone?
UncleBob
Errors
READY
COUNT: 15
100%


NDC.xlsx - Excel
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Wrap Text
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Conditional Formatting
Format as Table
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AutoSum
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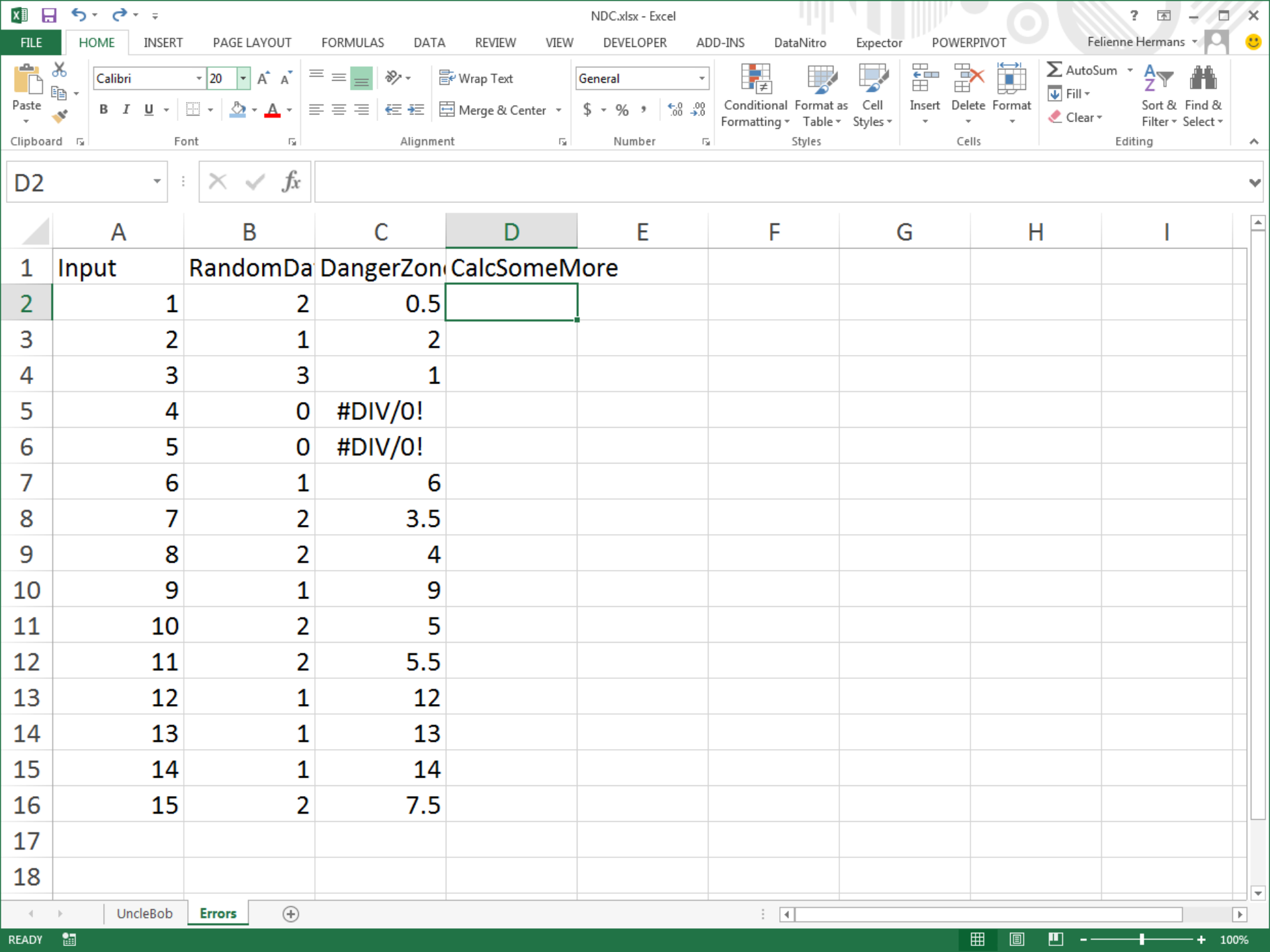
Find & Select
Clipboard
Font
Alignment
Number
Styles
Cells
Editing
C2
=A2/B2
Input
RandomDa
DangerZone!!!
1 2 0.5
2 1 2
3 3 1
4 0 #DIV/0!
5 0 #DIV/0!
6 1 6
7 2 3.5
8 2 4
9 1 9
10 2 5
11 2 5.5
12 1 12
13 1 13
14 1 14
15 2 7.5
What is the datatype of DangerZone?
It is a Maybe Int!
UncleBob
Errors
READY
COUNT: 15
100%


NDC.xlsx - Excel
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ADD-INS
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Felienne Hermans
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Conditional Formatting
Format as Table
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AutoSum
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Sort & Filter
Find & Select
Clipboard
Font
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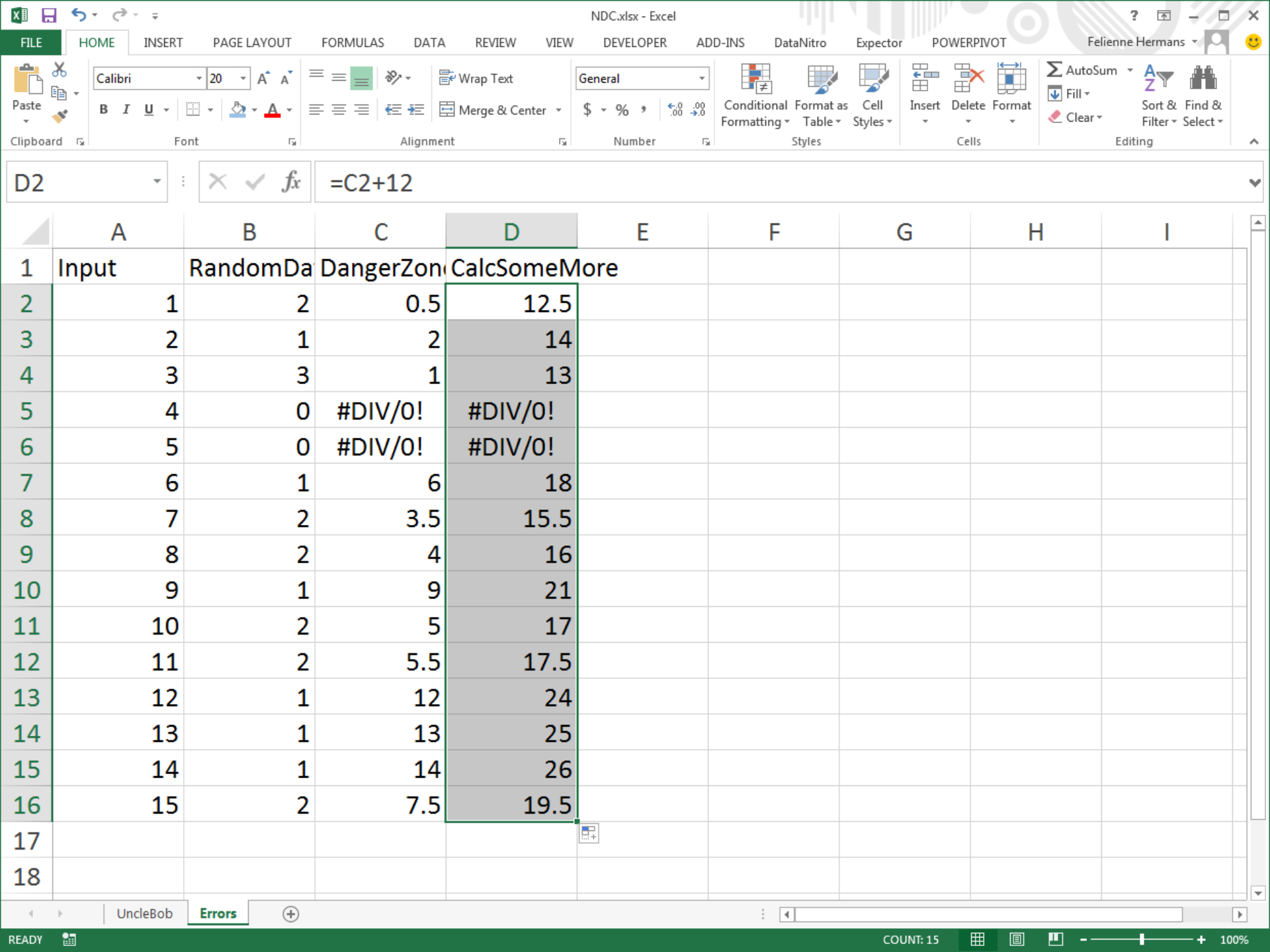
Number
Styles
Cells
Editing
D2
A
B
C
D
E
F
G
H
I
1 Input RandomDa DangerZon CalcSomeMore
2 1 2 0.5
3 2 1 2
4 3 3 1
5 4 0 #DIV/0!
6 5 0 #DIV/0!
7 6 1 6
8 7 2 3.5
9 8 2 4
10 9 1 9
11 10 2 5
12 11 2 5.5
13 12 1 12
14 13 1 13
15 14 1 14
16 15 2 7.5
17
18
UncleBob
Errors
READY
100%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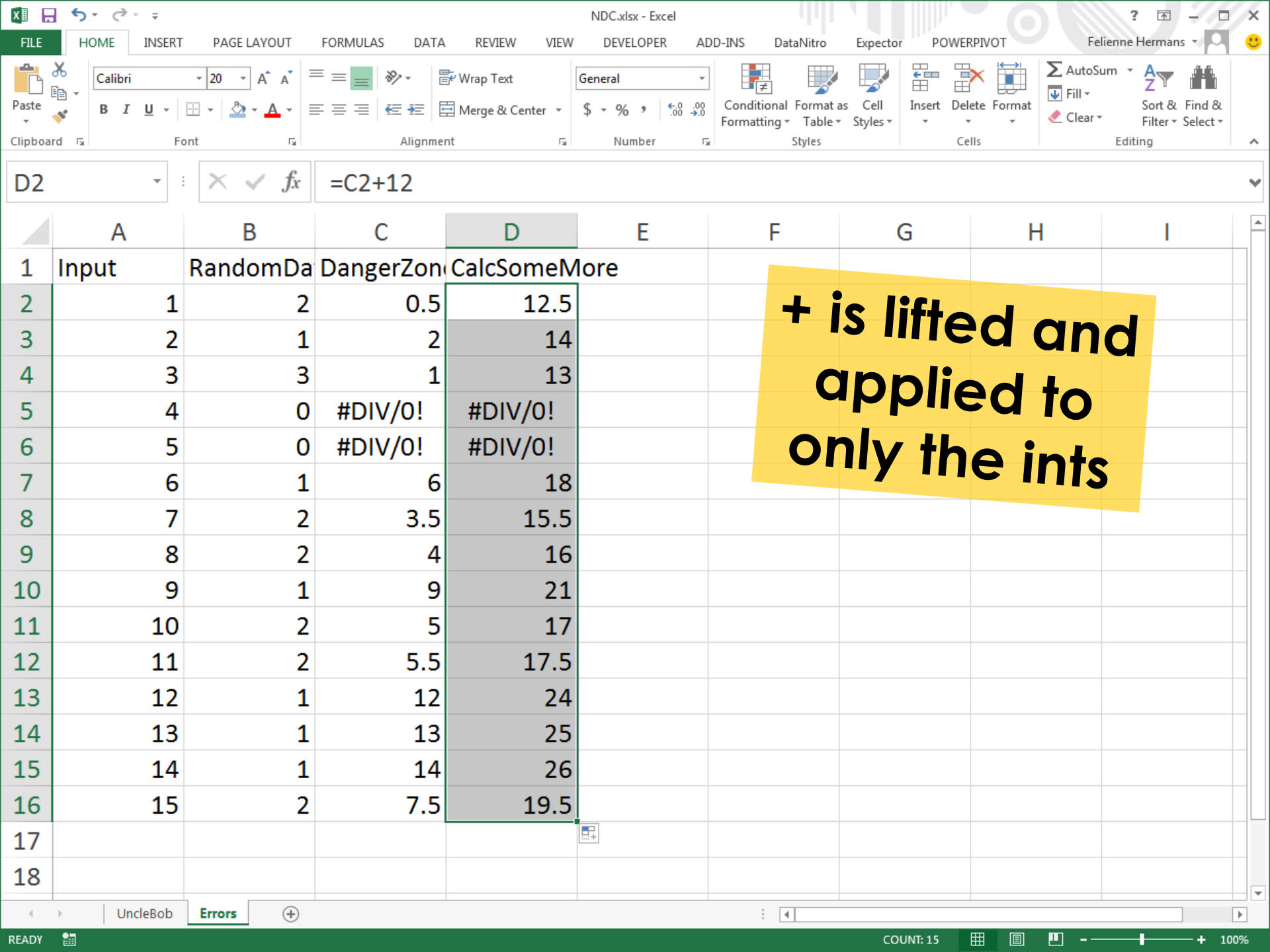
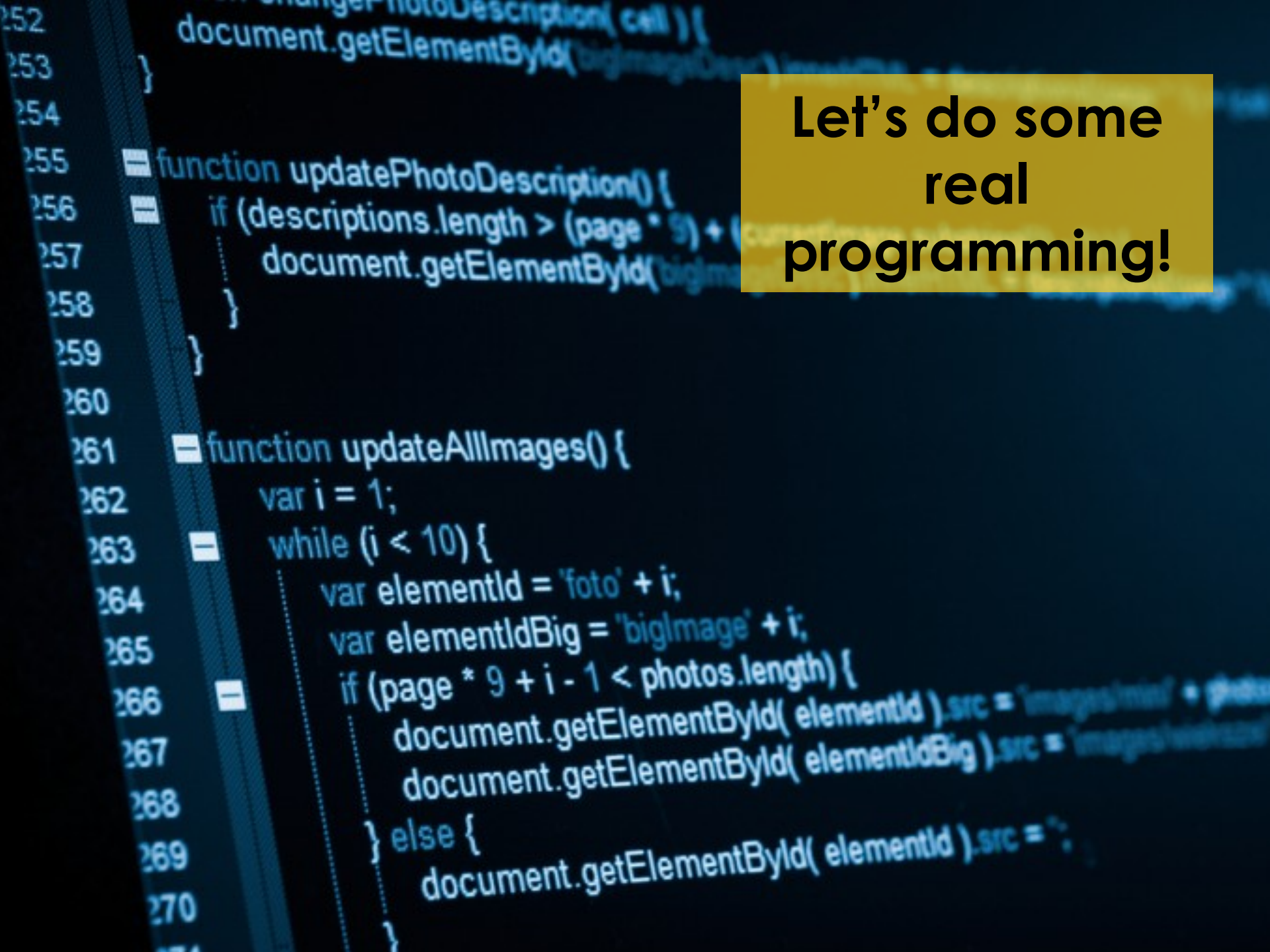
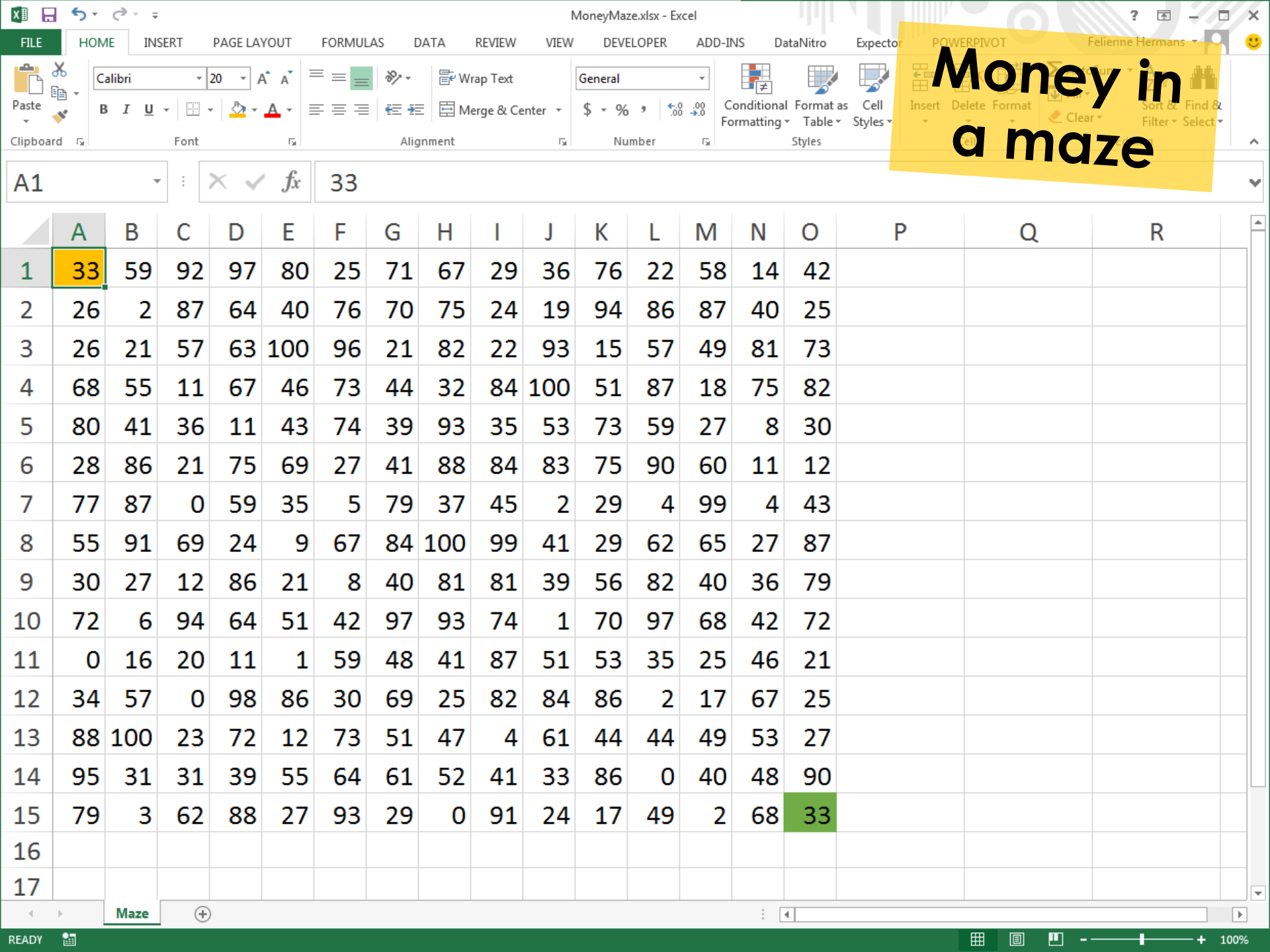
POWERPIVOT
Felienne Hermans
Paste
Calibri
20
Wrap Text
General
Merge & Center
Conditional Formatting
Format as Table
Cell Styles
Insert
Delete
Format
AutoSum
Fill
Clear
Sort & Filter
Find & Select
Clipboard
Font
Alignment
Number
Styles
Cells
Editing
D2
=C2+12
A
B
C
D
E
F
G
H
I
1 Input RandomDa DangerZon CalcSomeMore
2 1 2 0.5 12.5
3 2 1 2 14
4 3 3 1 13
5 4 0 #DIV/0! #DIV/0!
6 5 0 #DIV/0! #DIV/0!
7 6 1 6 18
8 7 2 3.5 15.5
9 8 2 4 16
10 9 1 9 21
11 10 2 5 17
12 11 2 5.5 17.5
13 12 1 12 24
14 13 1 13 25
15 14 1 14 26
16 15 2 7.5 19.5
17
18
UncleBob
Errors
READY
COUNT: 15
100%

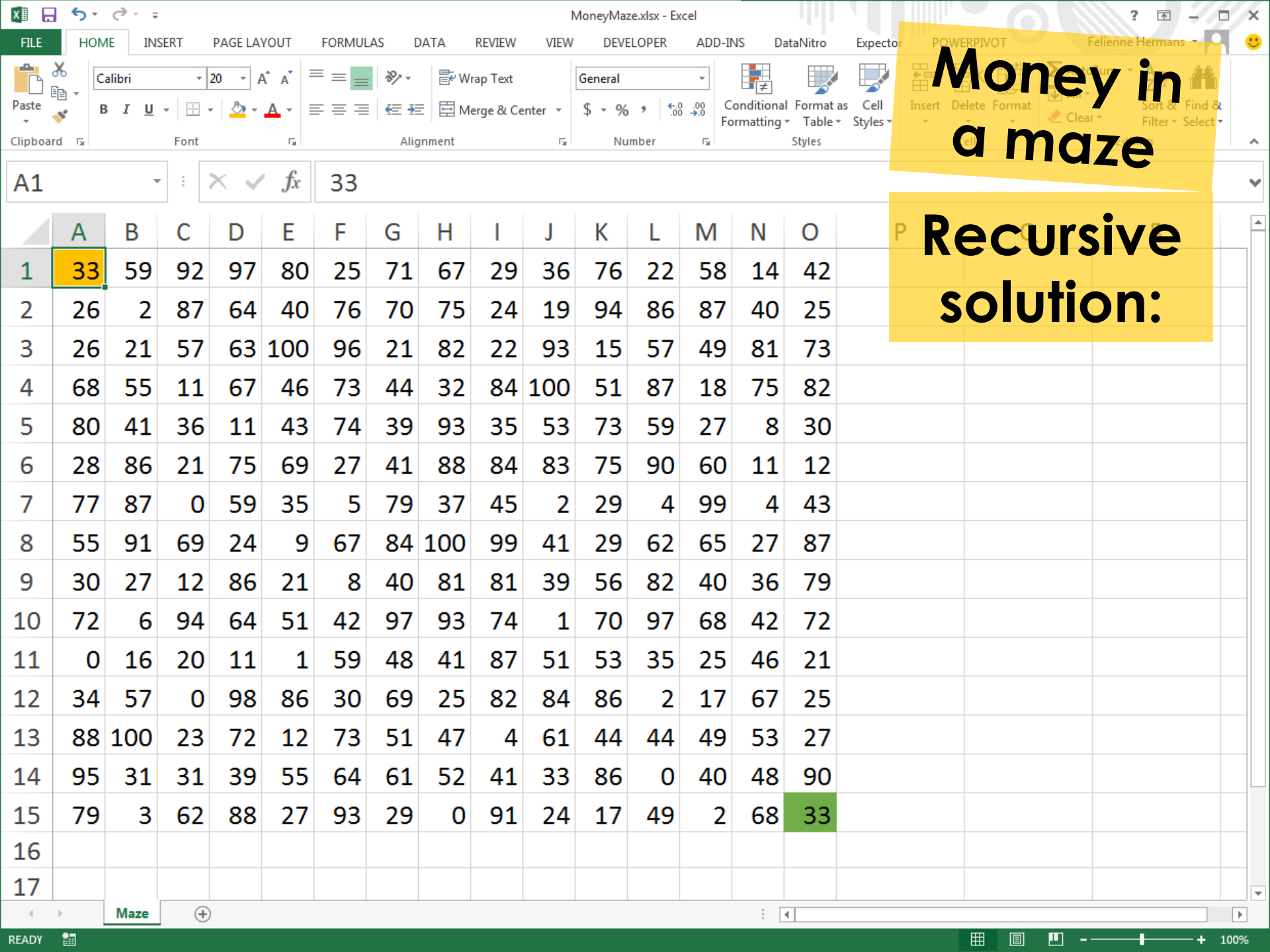


	A	B	C	D
1	Input	RandomDa	DangerZon	CalcSomeMore
2	1	2	0.5	12.5
3	2	1	2	14
4	3	3	1	13
5	4	0	#DIV/0!	#DIV/0!
6	5	0	#DIV/0!	#DIV/0!
7	6	1	6	18
8	7	2	3.5	15.5
9	8	2	4	16
10	9	1	9	21
11	10	2	5	17
12	11	2	5.5	17.5
13	12	1	12	24
14	13	1	13	25
15	14	1	14	26
16	15	2	7.5	19.5
17				
18				

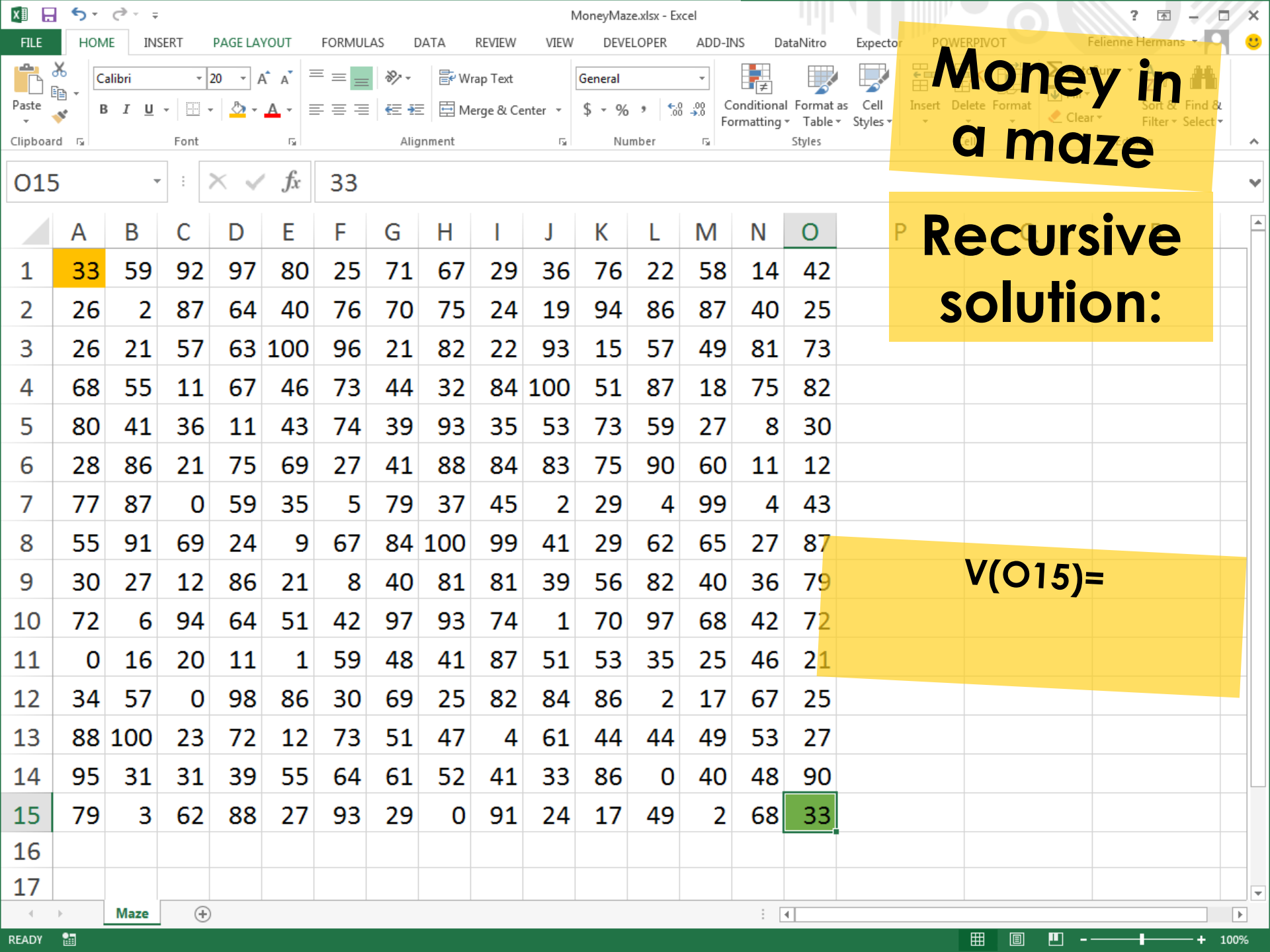

Let's do some real programming!
function updatePhotoDescription() {
if (descriptions.length > (page * 9) +
document.getElementById(
}
}
function updateAllImages() {
var i = 1;
while (i < 10) {
var elementId = 'foto' + i;
var elementIdBig = 'bigImage' + i;
if (page * 9 + i - 1 < photos.length) {
document.getElementById(elementId).src =
document.getElementById(elementIdBig).src =
} else {
document.getElementById(elementId).src = '';



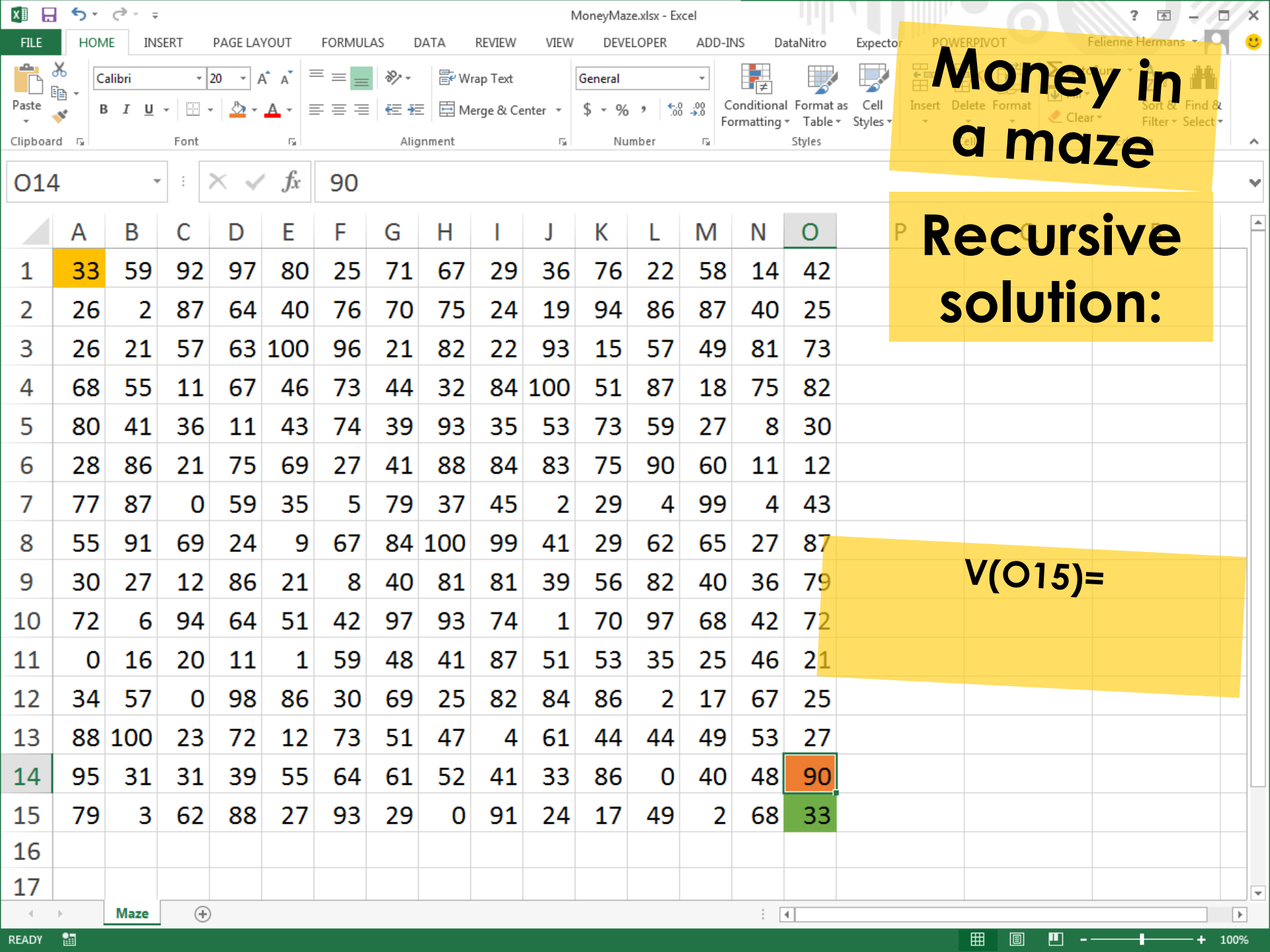
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	33	59	92	97	80	25	71	67	29	36	76	22	58	14	42
2	26	2	87	64	40	76	70	75	24	19	94	86	87	40	25
3	26	21	57	63	100	96	21	82	22	93	15	57	49	81	73
4	68	55	11	67	46	73	44	32	84	100	51	87	18	75	82
5	80	41	36	11	43	74	39	93	35	53	73	59	27	8	30
6	28	86	21	75	69	27	41	88	84	83	75	90	60	11	12
7	77	87	0	59	35	5	79	37	45	2	29	4	99	4	43
8	55	91	69	24	9	67	84	100	99	41	29	62	65	27	87
9	30	27	12	86	21	8	40	81	81	39	56	82	40	36	79
10	72	6	94	64	51	42	97	93	74	1	70	97	68	42	72
11	0	16	20	11	1	59	48	41	87	51	53	35	25	46	21
12	34	57	0	98	86	30	69	25	82	84	86	2	17	67	25
13	88	100	23	72	12	73	51	47	4	61	44	44	49	53	27
14	95	31	31	39	55	64	61	52	41	33	86	0	40	48	90
15	79	3	62	88	27	93	29	0	91	24	17	49	2	68	33
16															
17															



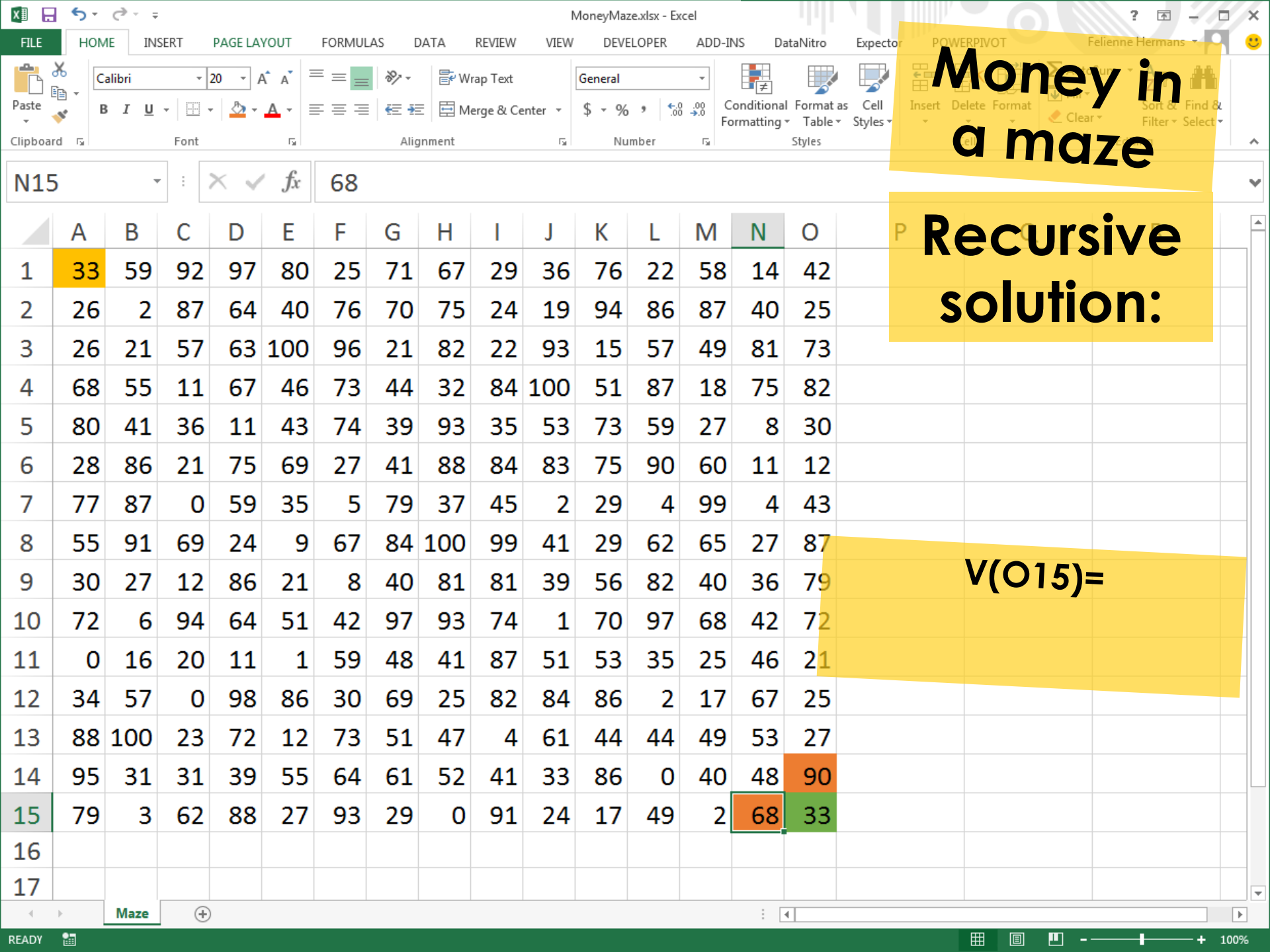
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	33	59	92	97	80	25	71	67	29	36	76	22	58	14	42
2	26	2	87	64	40	76	70	75	24	19	94	86	87	40	25
3	26	21	57	63	100	96	21	82	22	93	15	57	49	81	73
4	68	55	11	67	46	73	44	32	84	100	51	87	18	75	82
5	80	41	36	11	43	74	39	93	35	53	73	59	27	8	30
6	28	86	21	75	69	27	41	88	84	83	75	90	60	11	12
7	77	87	0	59	35	5	79	37	45	2	29	4	99	4	43
8	55	91	69	24	9	67	84	100	99	41	29	62	65	27	87
9	30	27	12	86	21	8	40	81	81	39	56	82	40	36	79
10	72	6	94	64	51	42	97	93	74	1	70	97	68	42	72
11	0	16	20	11	1	59	48	41	87	51	53	35	25	46	21
12	34	57	0	98	86	30	69	25	82	84	86	2	17	67	25
13	88	100	23	72	12	73	51	47	4	61	44	44	49	53	27
14	95	31	31	39	55	64	61	52	41	33	86	0	40	48	90
15	79	3	62	88	27	93	29	0	91	24	17	49	2	68	33
16															
17															



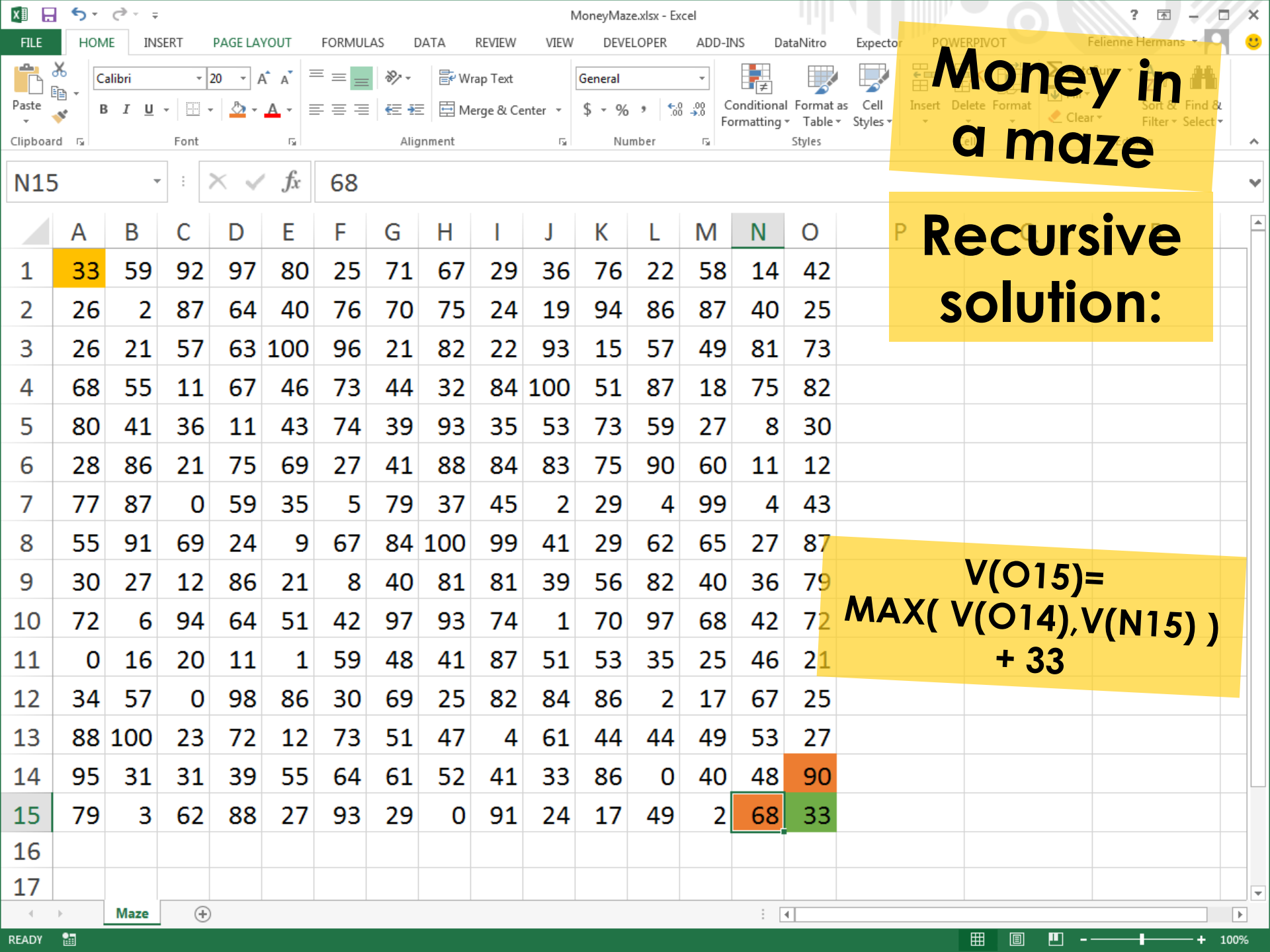
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	33	59	92	97	80	25	71	67	29	36	76	22	58	14	42
2	26	2	87	64	40	76	70	75	24	19	94	86	87	40	25
3	26	21	57	63	100	96	21	82	22	93	15	57	49	81	73
4	68	55	11	67	46	73	44	32	84	100	51	87	18	75	82
5	80	41	36	11	43	74	39	93	35	53	73	59	27	8	30
6	28	86	21	75	69	27	41	88	84	83	75	90	60	11	12
7	77	87	0	59	35	5	79	37	45	2	29	4	99	4	43
8	55	91	69	24	9	67	84	100	99	41	29	62	65	27	87
9	30	27	12	86	21	8	40	81	81	39	56	82	40	36	79
10	72	6	94	64	51	42	97	93	74	1	70	97	68	42	72
11	0	16	20	11	1	59	48	41	87	51	53	35	25	46	21
12	34	57	0	98	86	30	69	25	82	84	86	2	17	67	25
13	88	100	23	72	12	73	51	47	4	61	44	44	49	53	27
14	95	31	31	39	55	64	61	52	41	33	86	0	40	48	90
15	79	3	62	88	27	93	29	0	91	24	17	49	2	68	33
16															
17															



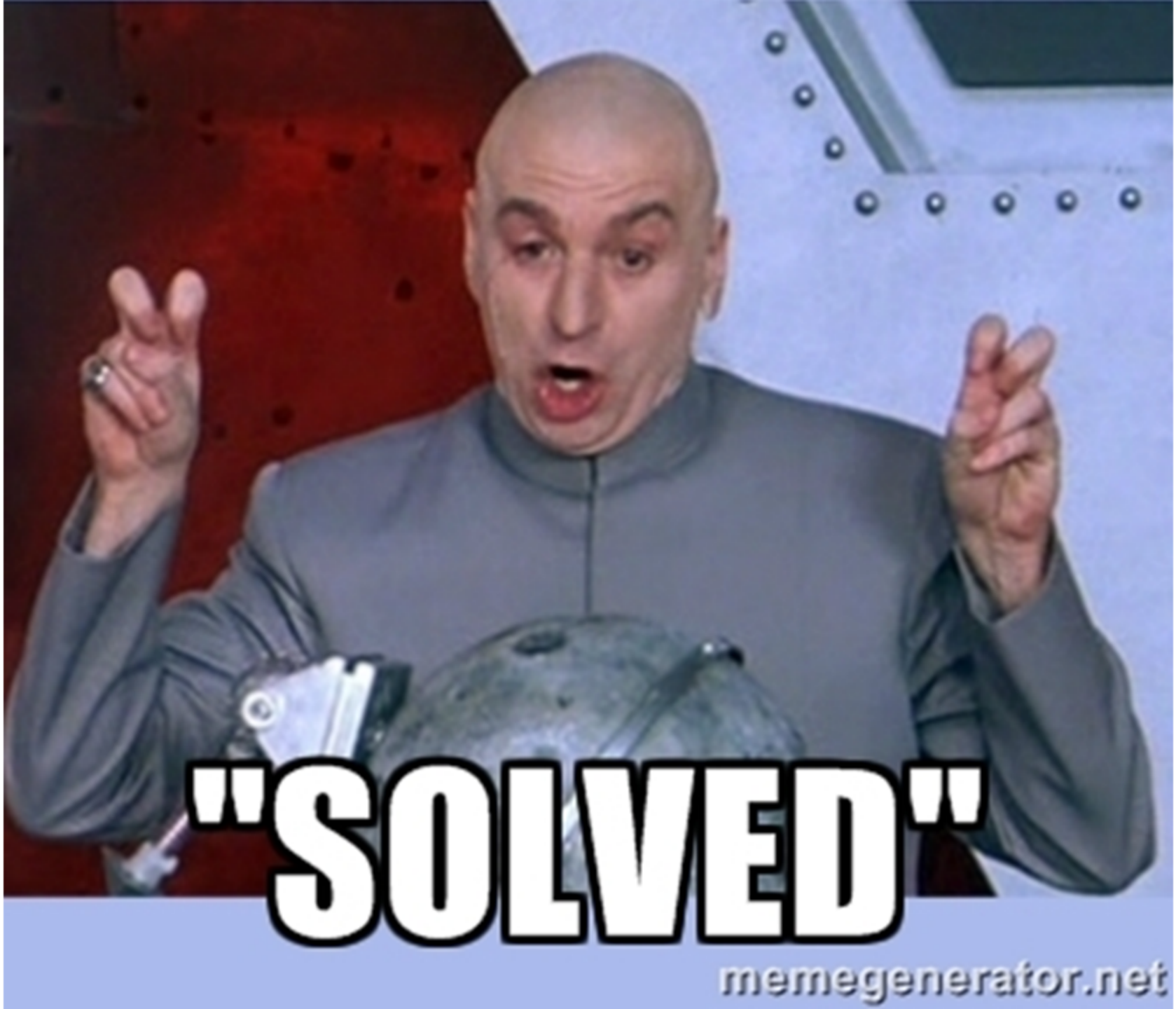
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	33	59	92	97	80	25	71	67	29	36	76	22	58	14	42
2	26	2	87	64	40	76	70	75	24	19	94	86	87	40	25
3	26	21	57	63	100	96	21	82	22	93	15	57	49	81	73
4	68	55	11	67	46	73	44	32	84	100	51	87	18	75	82
5	80	41	36	11	43	74	39	93	35	53	73	59	27	8	30
6	28	86	21	75	69	27	41	88	84	83	75	90	60	11	12
7	77	87	0	59	35	5	79	37	45	2	29	4	99	4	43
8	55	91	69	24	9	67	84	100	99	41	29	62	65	27	87
9	30	27	12	86	21	8	40	81	81	39	56	82	40	36	79
10	72	6	94	64	51	42	97	93	74	1	70	97	68	42	72
11	0	16	20	11	1	59	48	41	87	51	53	35	25	46	21
12	34	57	0	98	86	30	69	25	82	84	86	2	17	67	25
13	88	100	23	72	12	73	51	47	4	61	44	44	49	53	27
14	95	31	31	39	55	64	61	52	41	33	86	0	40	48	90
15	79	3	62	88	27	93	29	0	91	24	17	49	2	68	33
16															
17															

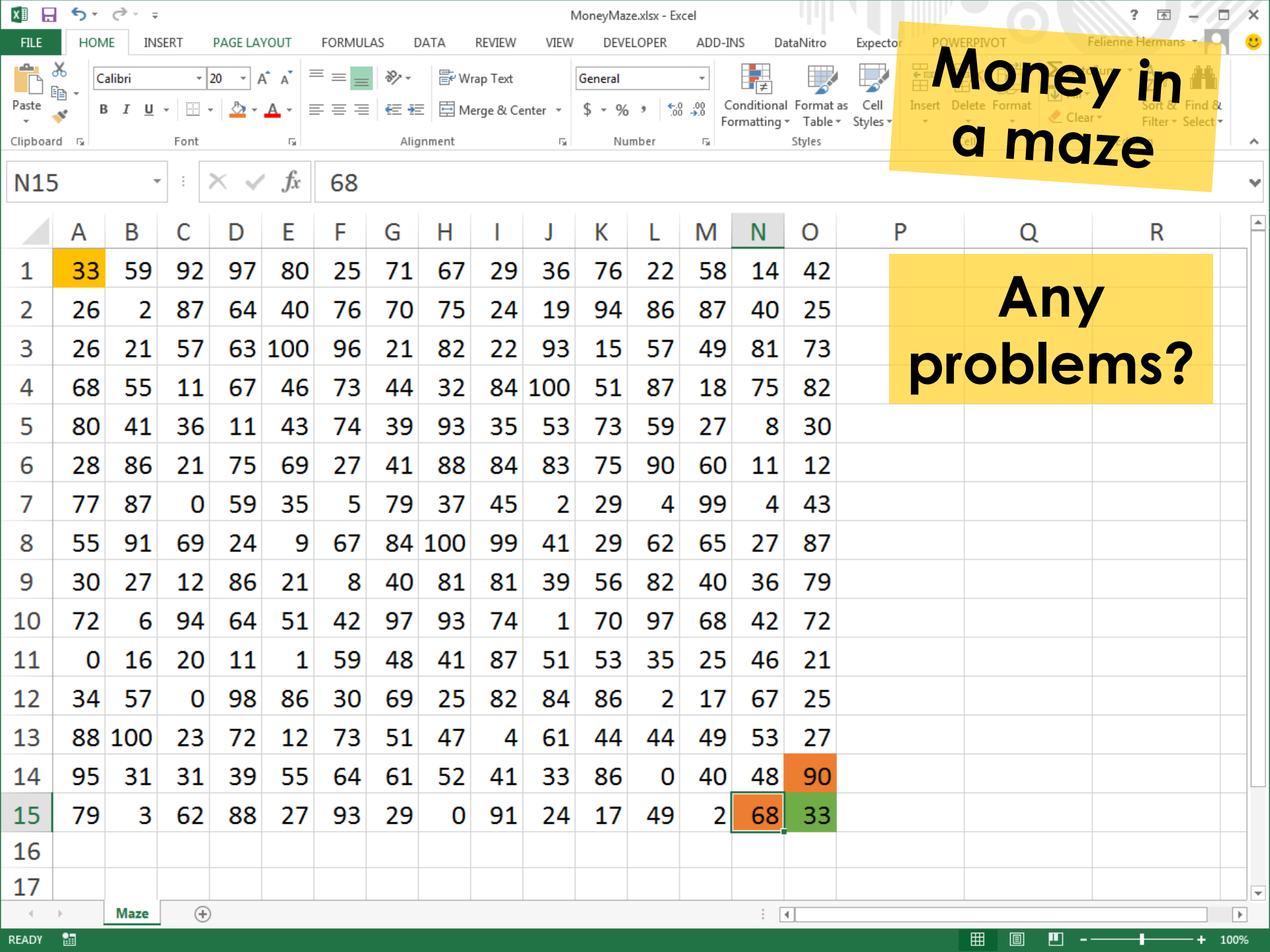


	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	33	59	92	97	80	25	71	67	29	36	76	22	58	14	42
2	26	2	87	64	40	76	70	75	24	19	94	86	87	40	25
3	26	21	57	63	100	96	21	82	22	93	15	57	49	81	73
4	68	55	11	67	46	73	44	32	84	100	51	87	18	75	82
5	80	41	36	11	43	74	39	93	35	53	73	59	27	8	30
6	28	86	21	75	69	27	41	88	84	83	75	90	60	11	12
7	77	87	0	59	35	5	79	37	45	2	29	4	99	4	43
8	55	91	69	24	9	67	84	100	99	41	29	62	65	27	87
9	30	27	12	86	21	8	40	81	81	39	56	82	40	36	79
10	72	6	94	64	51	42	97	93	74	1	70	97	68	42	72
11	0	16	20	11	1	59	48	41	87	51	53	35	25	46	21
12	34	57	0	98	86	30	69	25	82	84	86	2	17	67	25
13	88	100	23	72	12	73	51	47	4	61	44	44	49	53	27
14	95	31	31	39	55	64	61	52	41	33	86	0	40	48	90
15	79	3	62	88	27	93	29	0	91	24	17	49	2	68	33
16															
17															



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	33	59	92	97	80	25	71	67	29	36	76	22	58	14	42
2	26	2	87	64	40	76	70	75	24	19	94	86	87	40	25
3	26	21	57	63	100	96	21	82	22	93	15	57	49	81	73
4	68	55	11	67	46	73	44	32	84	100	51	87	18	75	82
5	80	41	36	11	43	74	39	93	35	53	73	59	27	8	30
6	28	86	21	75	69	27	41	88	84	83	75	90	60	11	12
7	77	87	0	59	35	5	79	37	45	2	29	4	99	4	43
8	55	91	69	24	9	67	84	100	99	41	29	62	65	27	87
9	30	27	12	86	21	8	40	81	81	39	56	82	40	36	79
10	72	6	94	64	51	42	97	93	74	1	70	97	68	42	72
11	0	16	20	11	1	59	48	41	87	51	53	35	25	46	21
12	34	57	0	98	86	30	69	25	82	84	86	2	17	67	25
13	88	100	23	72	12	73	51	47	4	61	44	44	49	53	27
14	95	31	31	39	55	64	61	52	41	33	86	0	40	48	90
15	79	3	62	88	27	93	29	0	91	24	17	49	2	68	33
16															
17															


"SOLVED"
memegenerator.net



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4	68	55	11	67	46	73	44	32	84	100	51	87	18	75	82
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11	0	16	20	11	1	59	48	41	87	51	53	35	25	46	21
12	34	57	0	98	86	30	69	25	82	84	86	2	17	67	25
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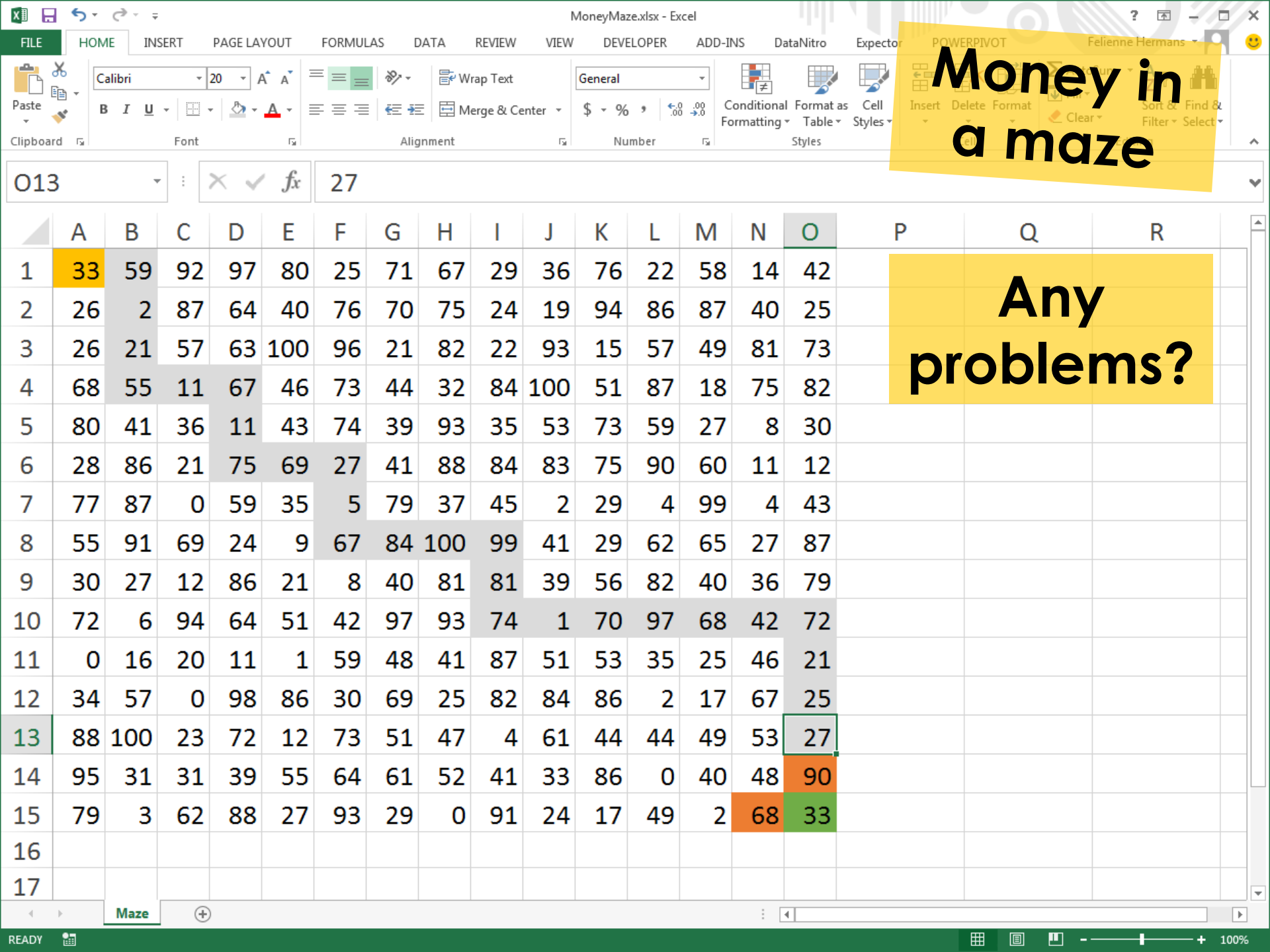
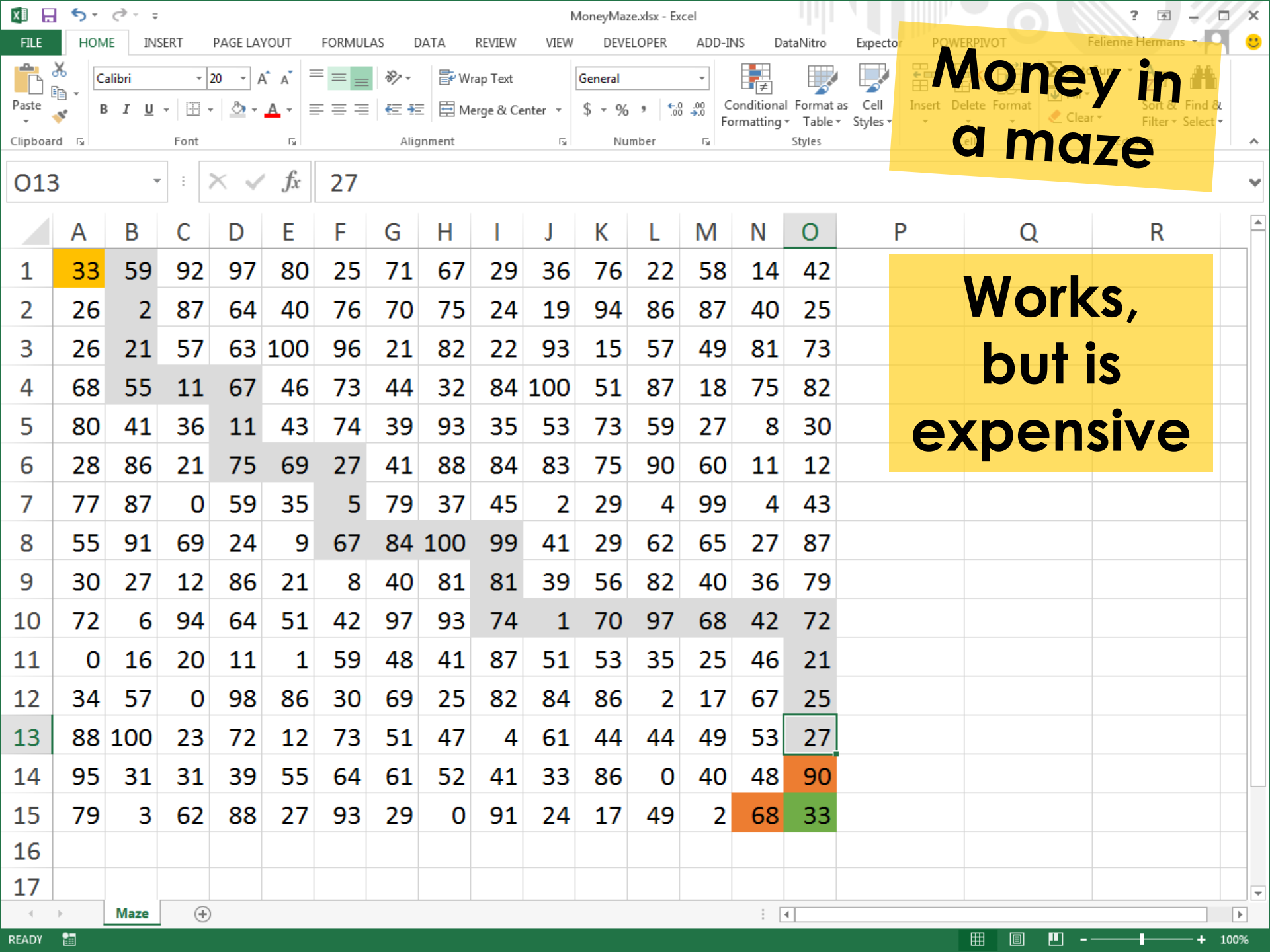
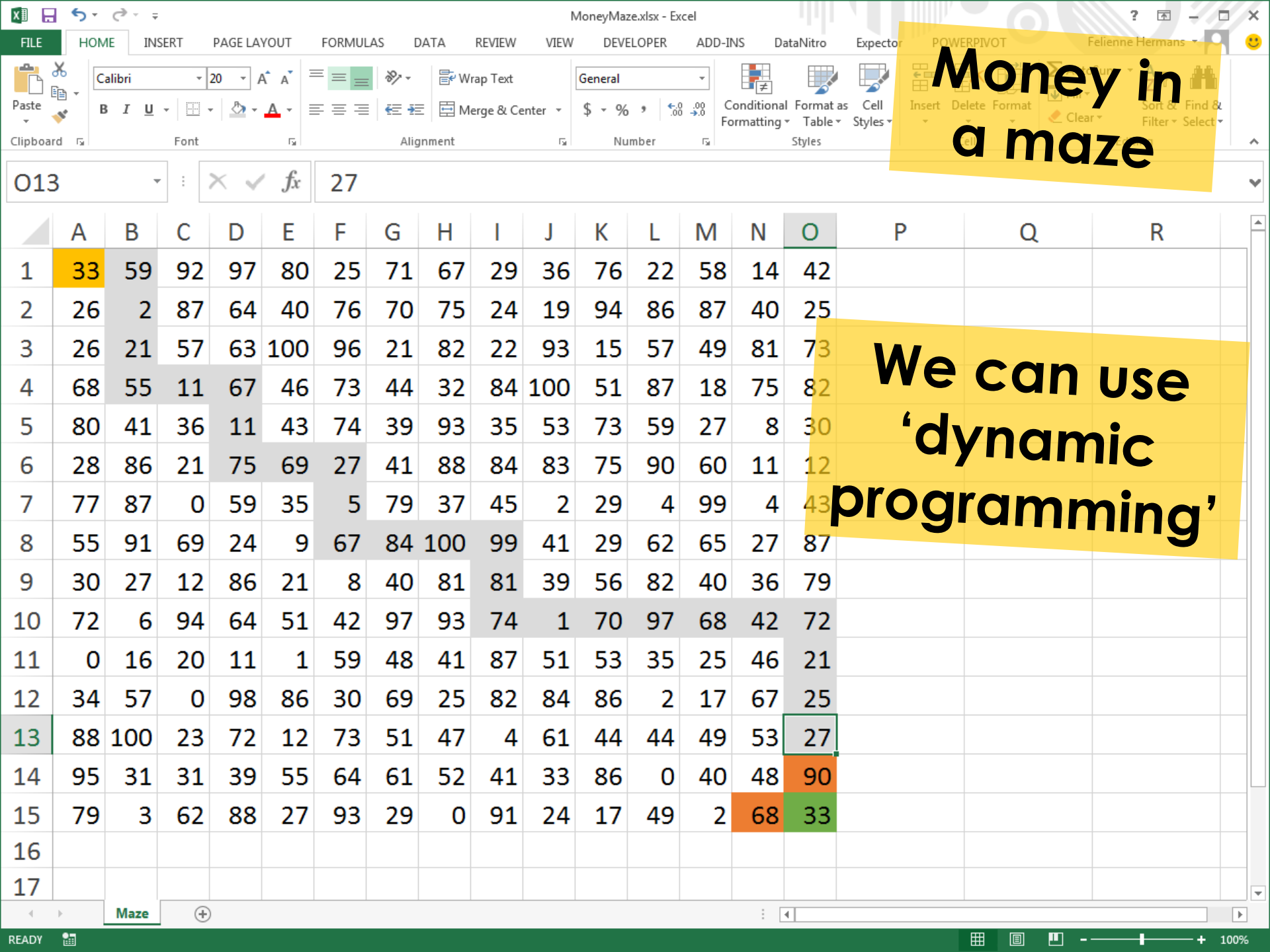
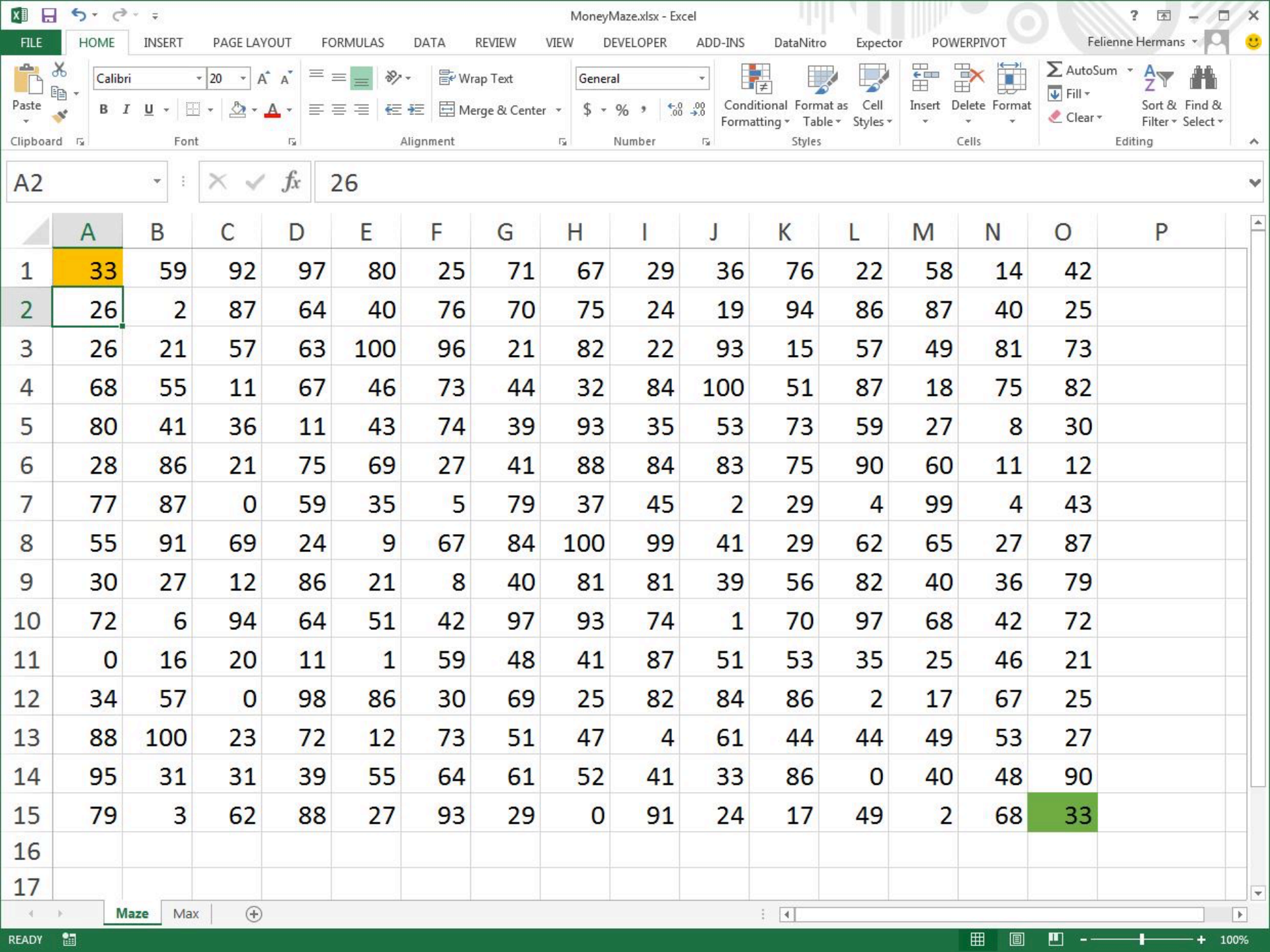
17															


MoneyMaze.xlsx - Excel
Money in a maze
Any problems?
O13
27
Maze
READY


MoneyMaze.xlsx - Excel
Money in a maze
Works, but is expensive
Maze
READY


MoneyMaze.xlsx - Excel
Money in a maze
We can use 'dynamic programming'
Maze
READY



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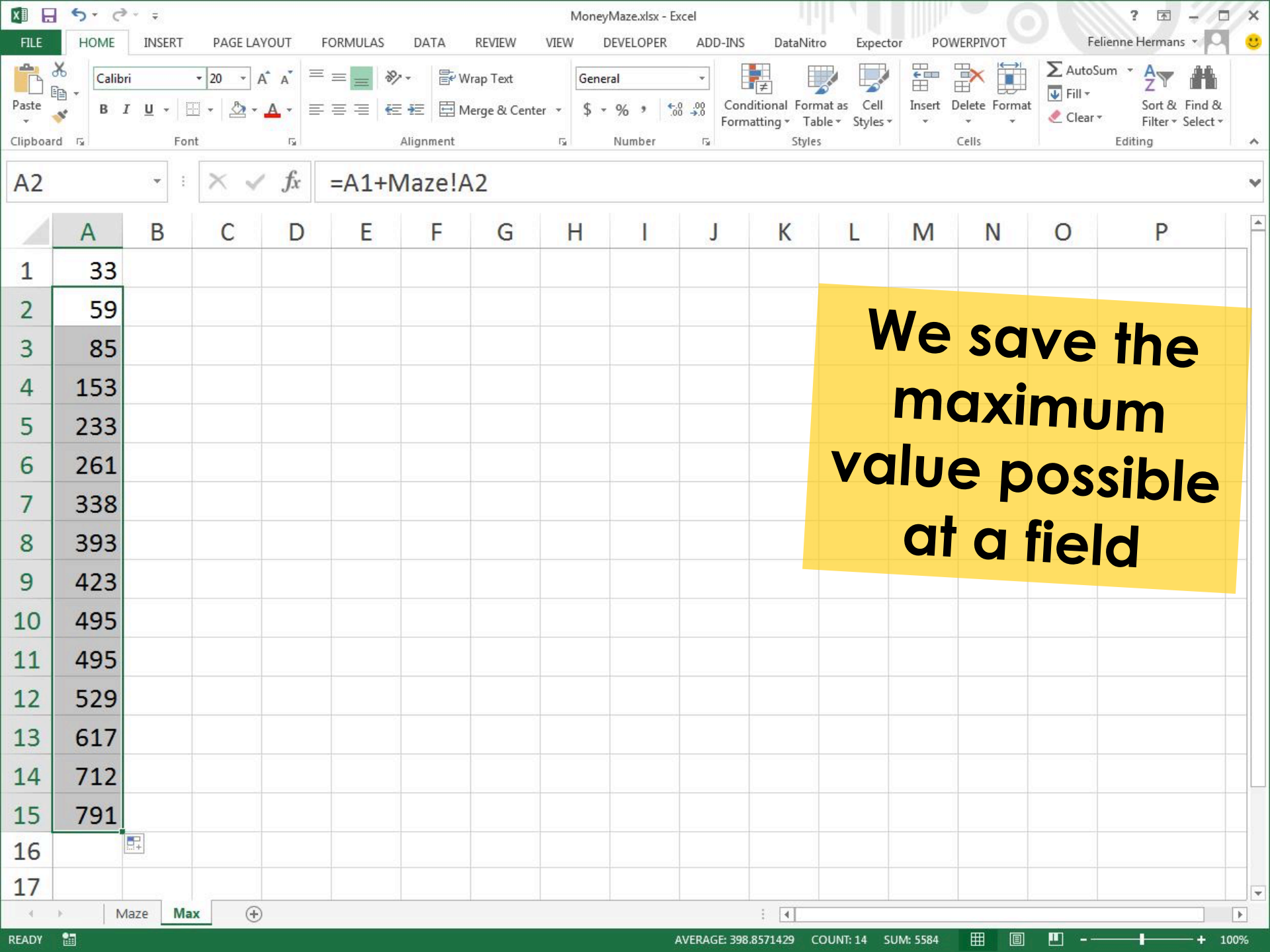
MoneyMaze.xlsx - Excel
FILE
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DATA
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ADD-INS
DataNitro
Expector
POWERPIVOT
Felienne Hermans
Paste
Calibri
20
Wrap Text
General
Merge & Center
Conditional Formatting
Format as Table
Cell Styles
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AutoSum
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Clear
Sort & Filter
Find & Select
Clipboard
Font
Alignment
Number
Styles
Cells
Editing
A2
=A1+Maze!A2
A B C D E F G H I J K L M N O P
1 33
2 59
3 85
4 153
5 233
6 261
7 338
8 393
9 423
10 495
11 495
12 529
13 617
14 712
15 791
16
17
We save the maximum value possible at a field
Maze
Max
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COUNT: 14
SUM: 5584
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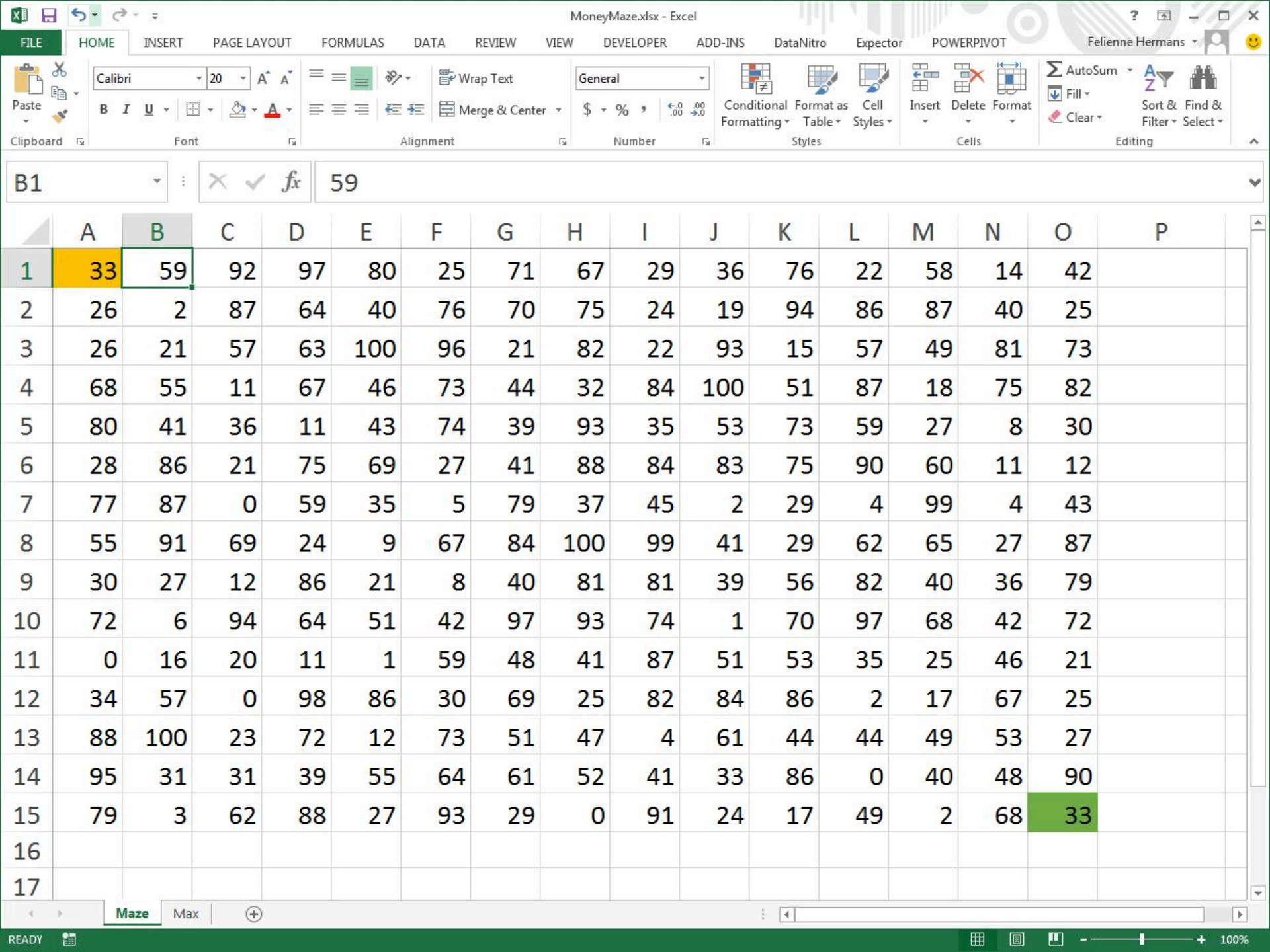

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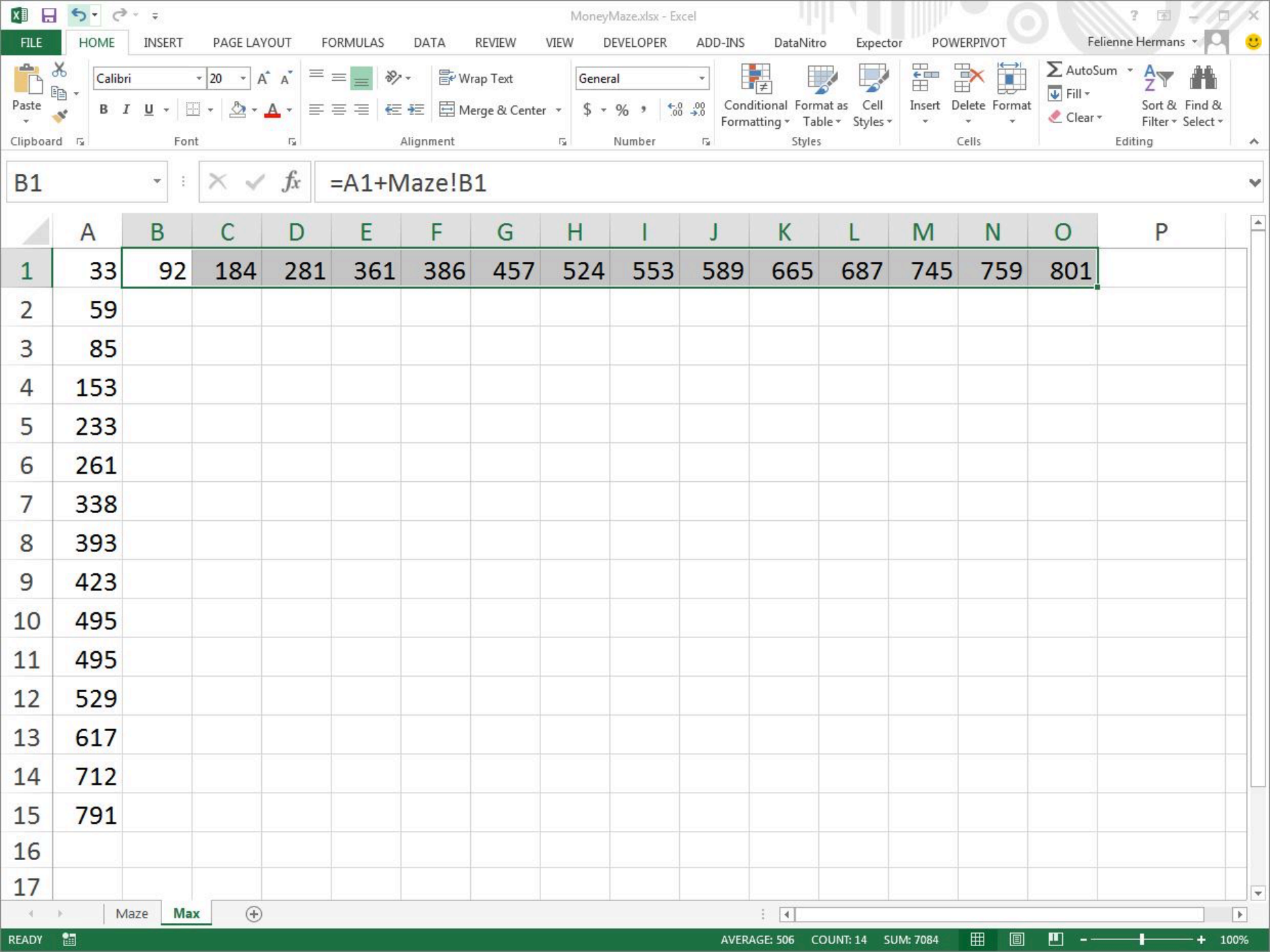
MoneyMaze.xlsx - Excel
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ADD-INS
DataNitro
Expector
POWERPIVOT
Felienne Hermans
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Format as Table
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Sort & Filter
Find & Select
Clipboard
Font
Alignment
Number
Styles
Cells
Editing
B1
=A1+Maze!B1
A B C D E F G H I J K L M N O P
1 33 92 184 281 361 386 457 524 553 589 665 687 745 759 801
2 59
3 85
4 153
5 233
6 261
7 338
8 393
9 423
10 495
11 495
12 529
13 617
14 712
15 791
16
17
Maze
Max
READY
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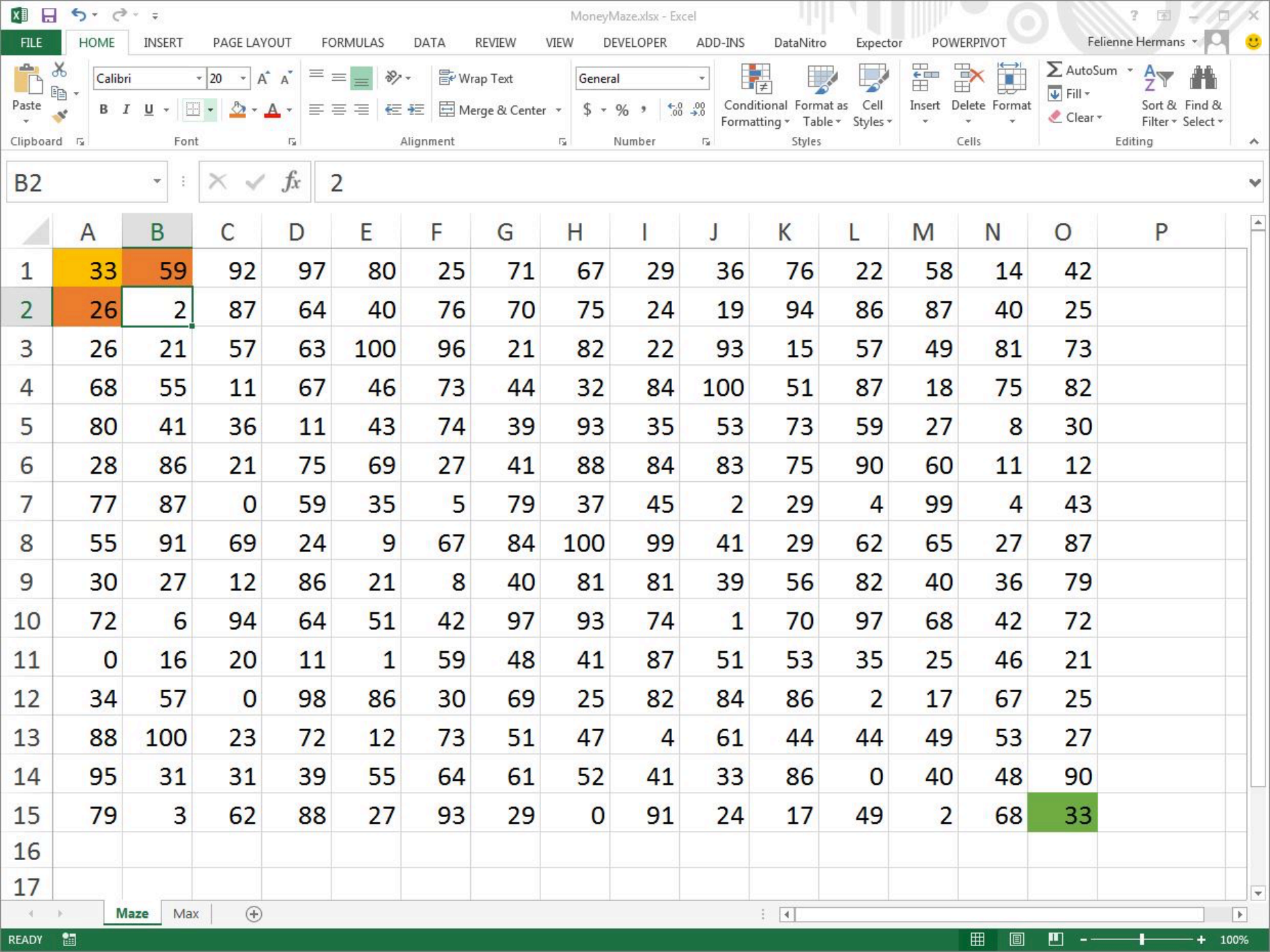
100%



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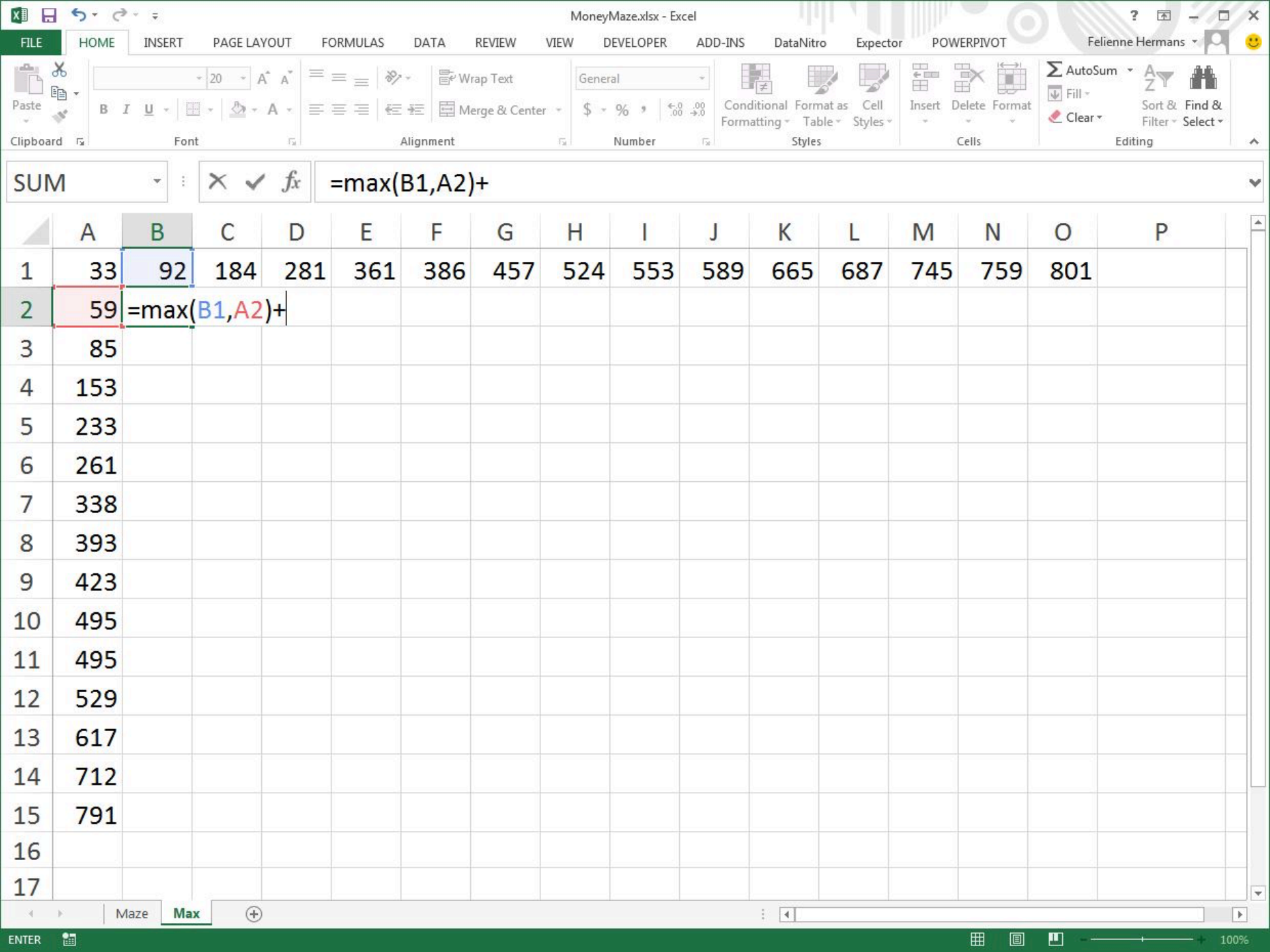
MoneyMaze.xlsx - Excel
FILE
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POWERPIVOT
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Cell Styles
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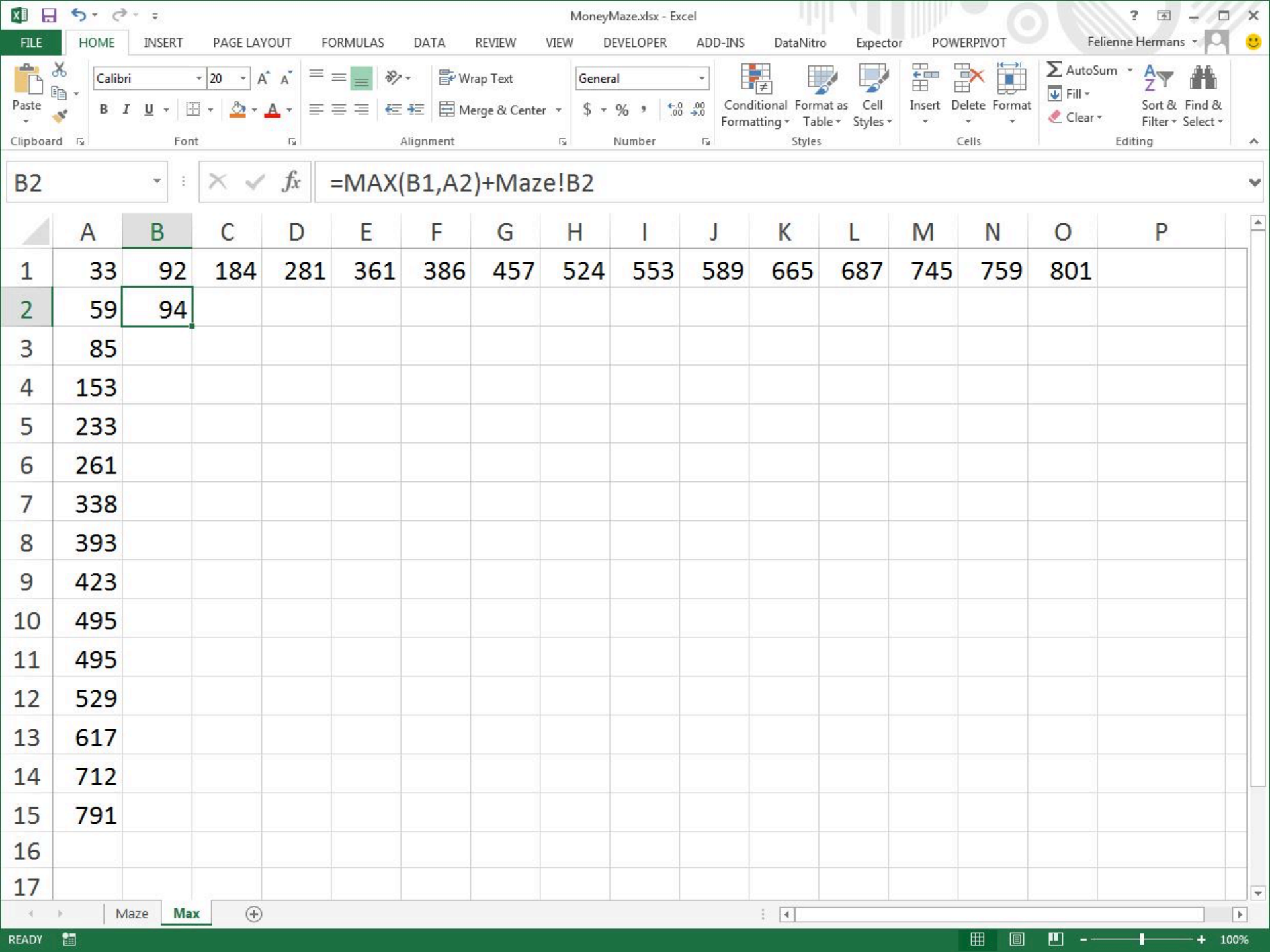
AutoSum
Fill
Clear
Sort & Filter
Find & Select
Editing
SUM
=max(B1,A2)+
A B C D E F G H I J K L M N O P
1 33 92 184 281 361 386 457 524 553 589 665 687 745 759 801
2 59 =max(B1,A2)+
3 85
4 153
5 233
6 261
7 338
8 393
9 423
10 495
11 495
12 529
13 617
14 712
15 791
16
17
Maze
Max
ENTER
100%



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
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2	59	94														
3	85															
4	153															
5	233															
6	261															
7	338															
8	393															
9	423															
10	495															
11	495															
12	529															
13	617															
14	712															
15	791															
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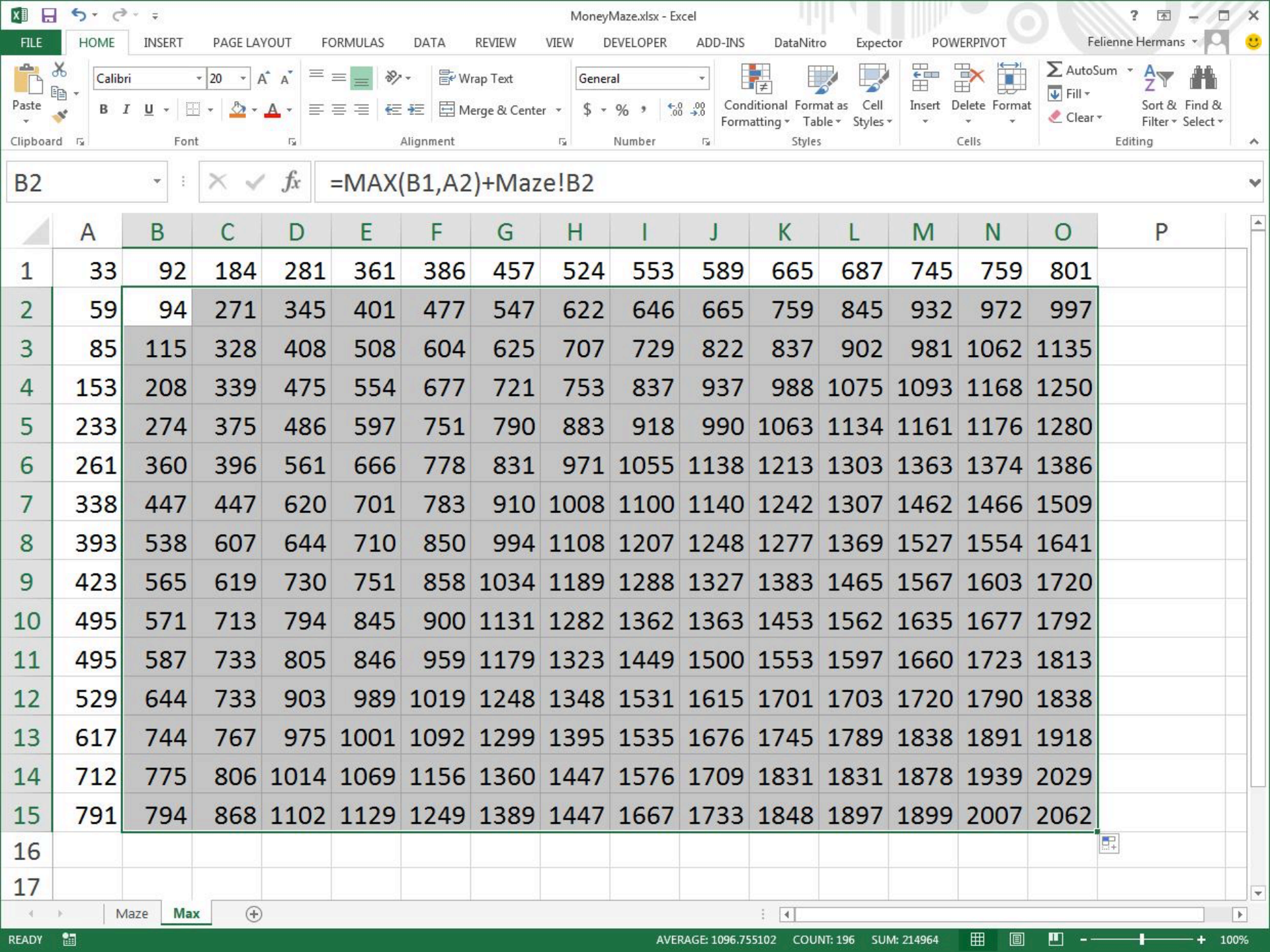

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
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2	59	94	271	345	401	477	547	622	646	665	759	845	932	972	997	
3	85	115	328	408	508	604	625	707	729	822	837	902	981	1062	1135	
4	153	208	339	475	554	677	721	753	837	937	988	1075	1093	1168	1250	
5	233	274	375	486	597	751	790	883	918	990	1063	1134	1161	1176	1280	
6	261	360	396	561	666	778	831	971	1055	1138	1213	1303	1363	1374	1386	
7	338	447	447	620	701	783	910	1008	1100	1140	1242	1307	1462	1466	1509	
8	393	538	607	644	710	850	994	1108	1207	1248	1277	1369	1527	1554	1641	
9	423	565	619	730	751	858	1034	1189	1288	1327	1383	1465	1567	1603	1720	
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14	712	775	806	1014	1069	1156	1360	1447	1576	1709	1831	1831	1878	1939	2029	
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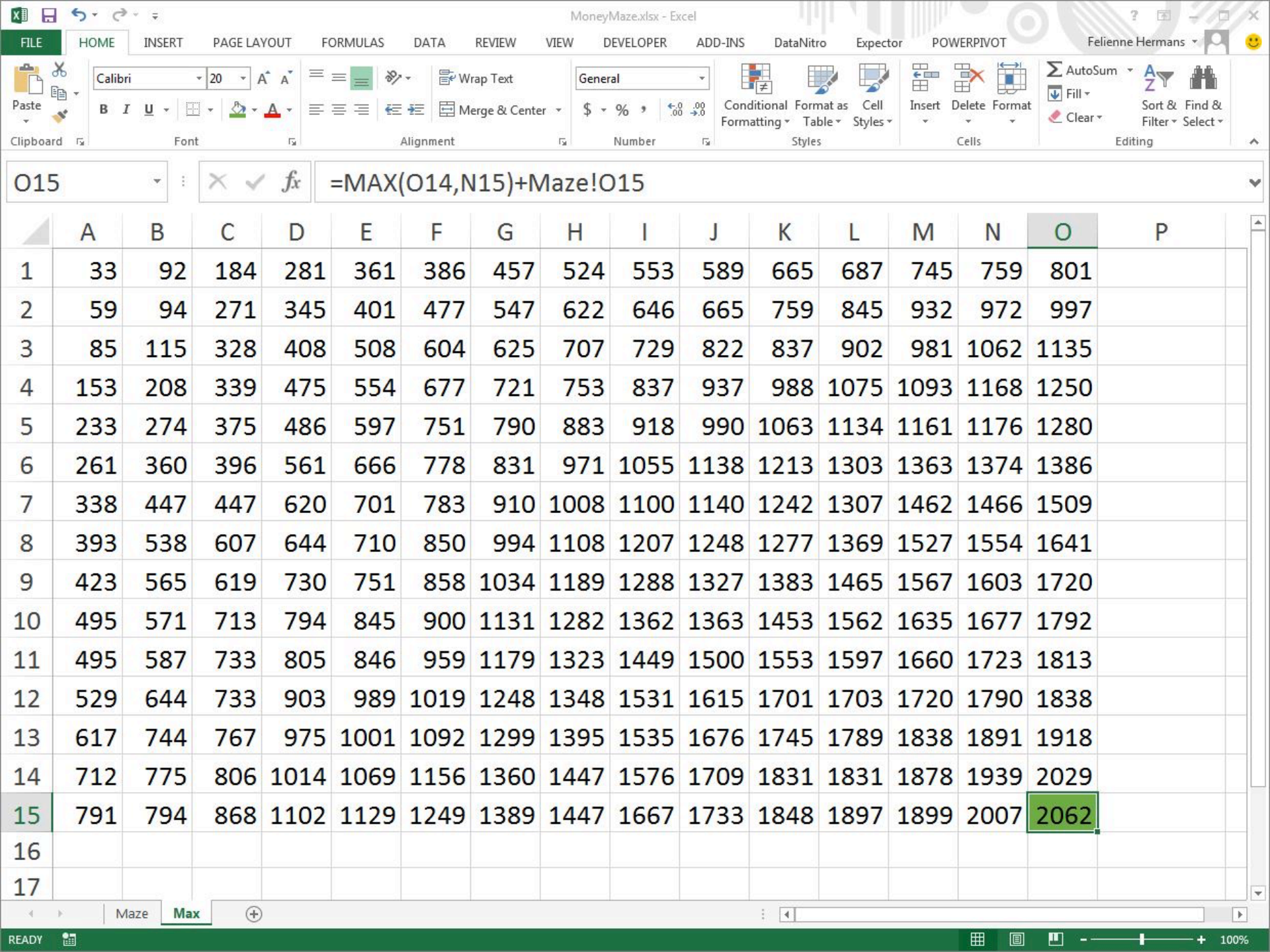

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5	233	274	375	486	597	751	790	883	918	990	1063	1134	1161	1176	1280	
6	261	360	396	561	666	778	831	971	1055	1138	1213	1303	1363	1374	1386	
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8	393	538	607	644	710	850	994	1108	1207	1248	1277	1369	1527	1554	1641	
9	423	565	619	730	751	858	1034	1189	1288	1327	1383	1465	1567	1603	1720	
10	495	571	713	794	845	900	1131	1282	1362	1363	1453	1562	1635	1677	1792	
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12	529	644	733	903	989	1019	1248	1348	1531	1615	1701	1703	1720	1790	1838	
13	617	744	767	975	1001	1092	1299	1395	1535	1676	1745	1789	1838	1891	1918	
14	712	775	806	1014	1069	1156	1360	1447	1576	1709	1831	1831	1878	1939	2029	
15	791	794	868	1102	1129	1249	1389	1447	1667	1733	1848	1897	1899	2007	2062	
16																
17																

C

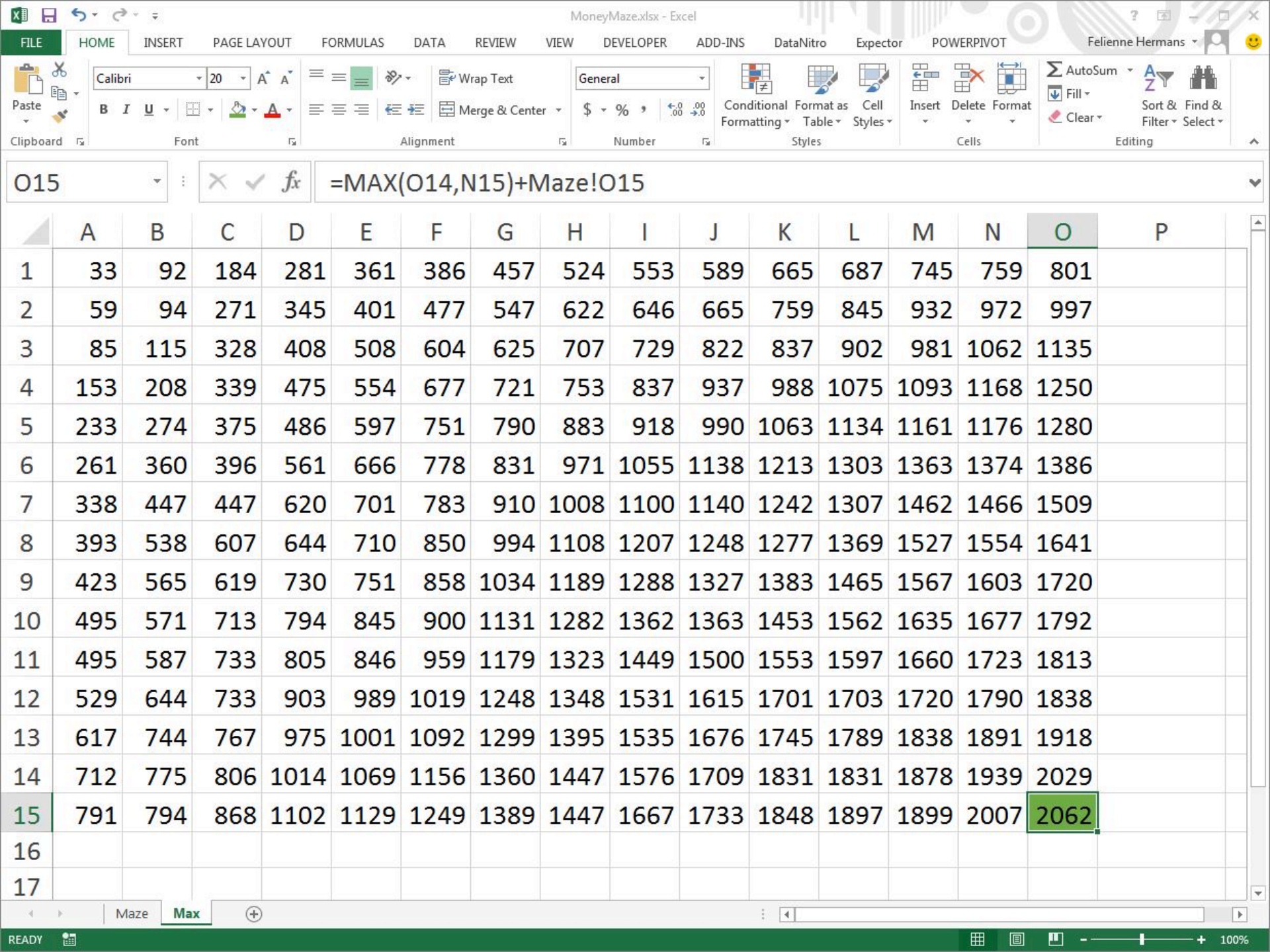
```c
#include <stdio.h>
#include <math.h>

#define max(x,y)  ((x) > (y) ? (x) : (y))

int main(void)
{
    const int len  = sizeof(tri) / sizeof(tri[0]);
    const int base = (sqrt(8*len + 1) - 1) / 2;
    int step       = base - 1;
    int stepc      = 0;

    int i;
    for (i = len - base - 1; i >= 0; --i) {
        tri[i] += max(tri[i + step], tri[i + step + 1]);
        if (++stepc == step) {
            step--;
            stepc = 0;
        }
    }

    printf("%d\n", tri[0]);
    return 0;
}
```

C

```c
#include <stdio.h>
#include <math.h>

#define max(x,y)  ((x) > (y) ? (x) : (y))

int main(void)
{
    const int len  = sizeof(tri) / sizeof(tri[0]);
    const int base = (sqrt(8*len + 1) - 1) / 2;
    int step       = base - 1;
    int stepc      = 0;

    int i;
    for (i = len - base - 1; i >= 0; --i) {
        tri[i] += max(tri[i + step], tri[i + step + 1]);
        if (++stepc == step) {
            step--;
            stepc = 0;
        }
    }

    printf("%d\n", tri[0]);
    return 0;
}
```

Haskell

```haskell
parse = map (map read . words) . lines
f x y z = x + max y z
g xs ys = zipWith3 f xs ys $ tail ys
solve = head . foldr1 g
main = readFile "triangle.txt" >>= print . solve . parse
```



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
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4	153	208	339	475	554	677	721	753	837	937	988	1075	1093	1168	1250	
5	233	274	375	486	597	751	790	883	918	990	1063	1134	1161	1176	1280	
6	261	360	396	561	666	778	831	971	1055	1138	1213	1303	1363	1374	1386	
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12	529	644	733	903	989	1019	1248	1348	1531	1615	1701	1703	1720	1790	1838	
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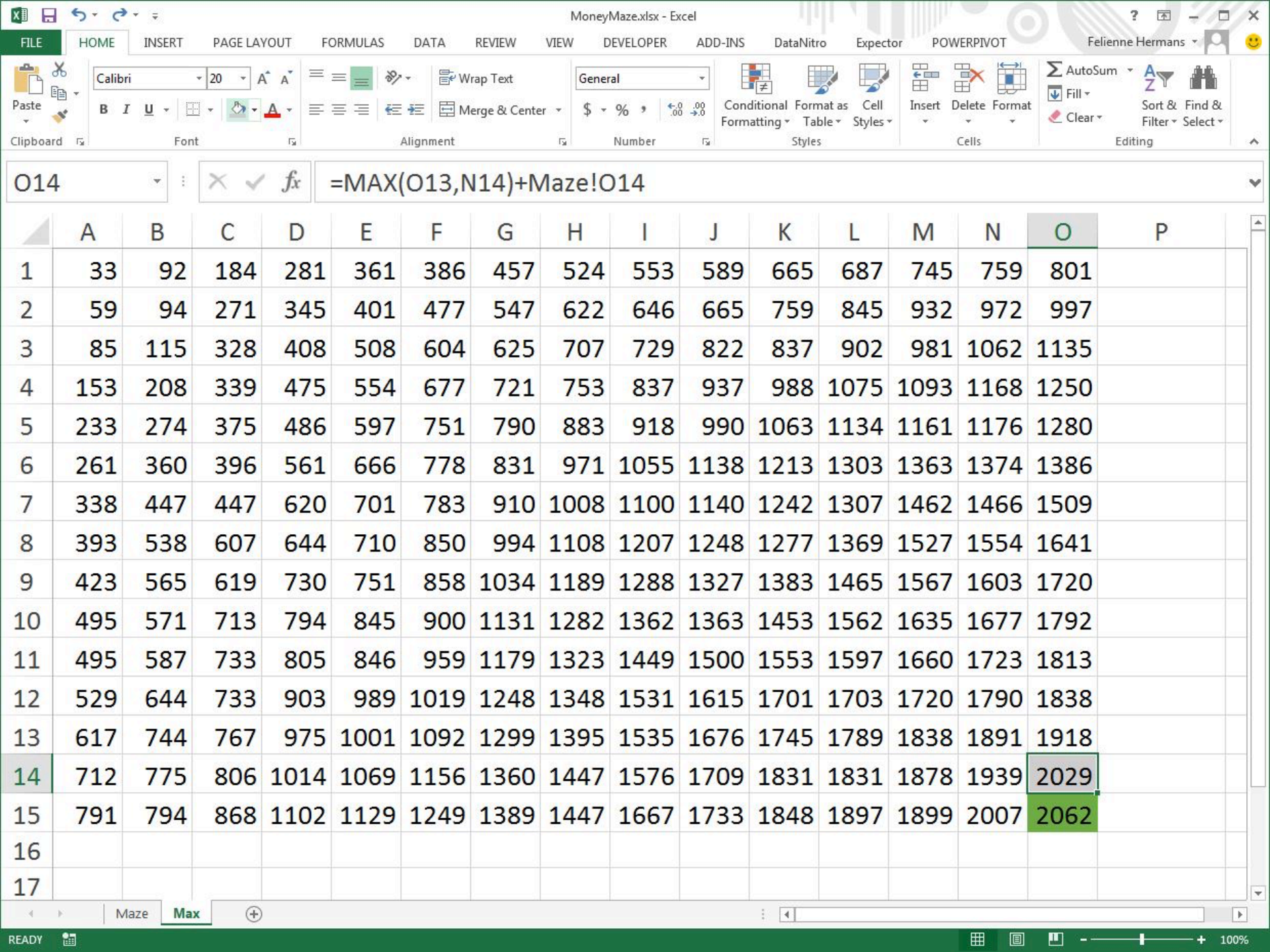

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
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8	393	538	607	644	710	850	994	1108	1207	1248	1277	1369	1527	1554	1641	
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11	495	587	733	805	846	959	1179	1323	1449	1500	1553	1597	1660	1723	1813	
12	529	644	733	903	989	1019	1248	1348	1531	1615	1701	1703	1720	1790	1838	
13	617	744	767	975	1001	1092	1299	1395	1535	1676	1745	1789	1838	1891	1918	
14	712	775	806	1014	1069	1156	1360	1447	1576	1709	1831	1831	1878	1939	2029	
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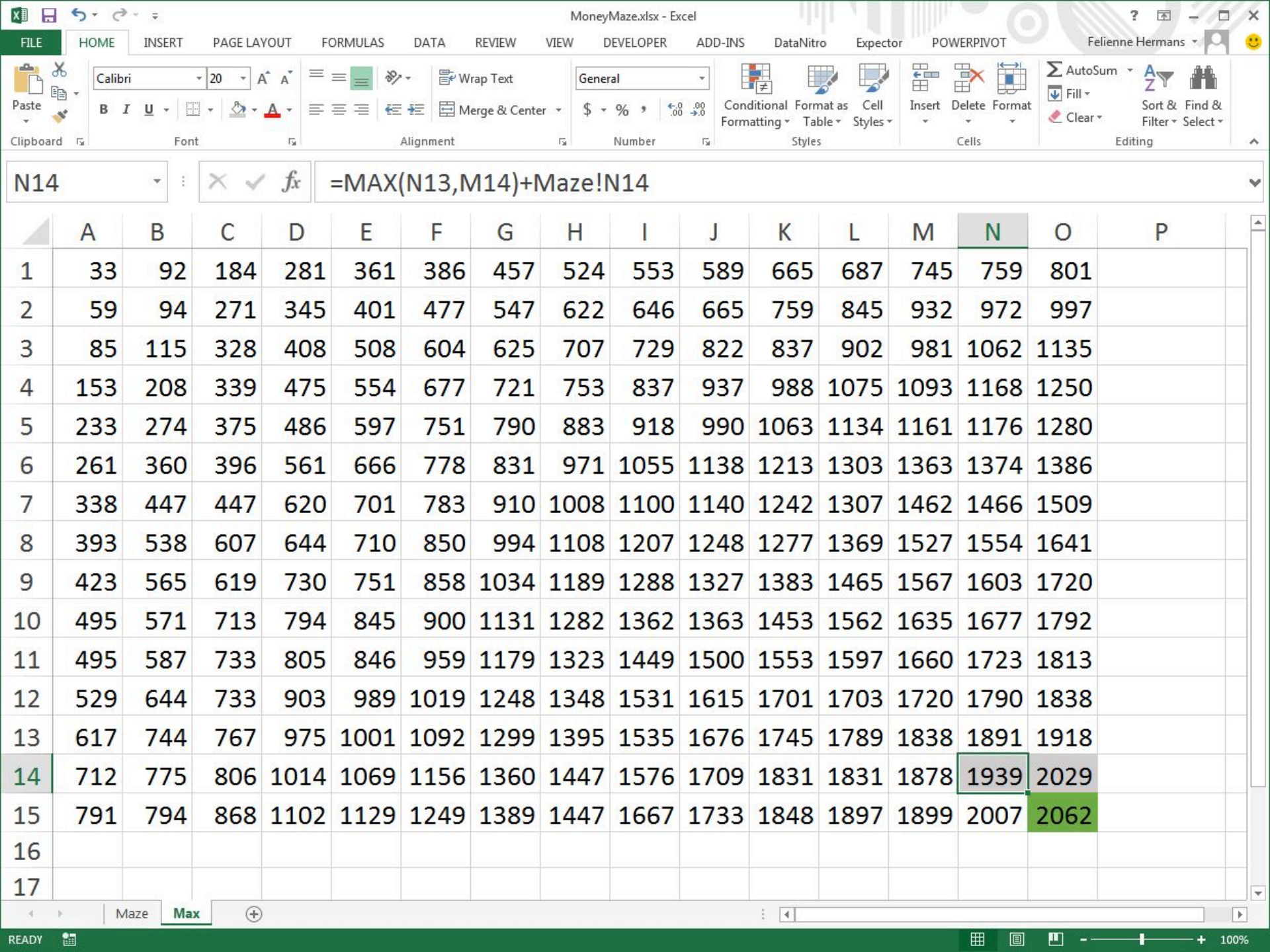

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3	85	115	328	408	508	604	625	707	729	822	837	902	981	1062	1135	
4	153	208	339	475	554	677	721	753	837	937	988	1075	1093	1168	1250	
5	233	274	375	486	597	751	790	883	918	990	1063	1134	1161	1176	1280	
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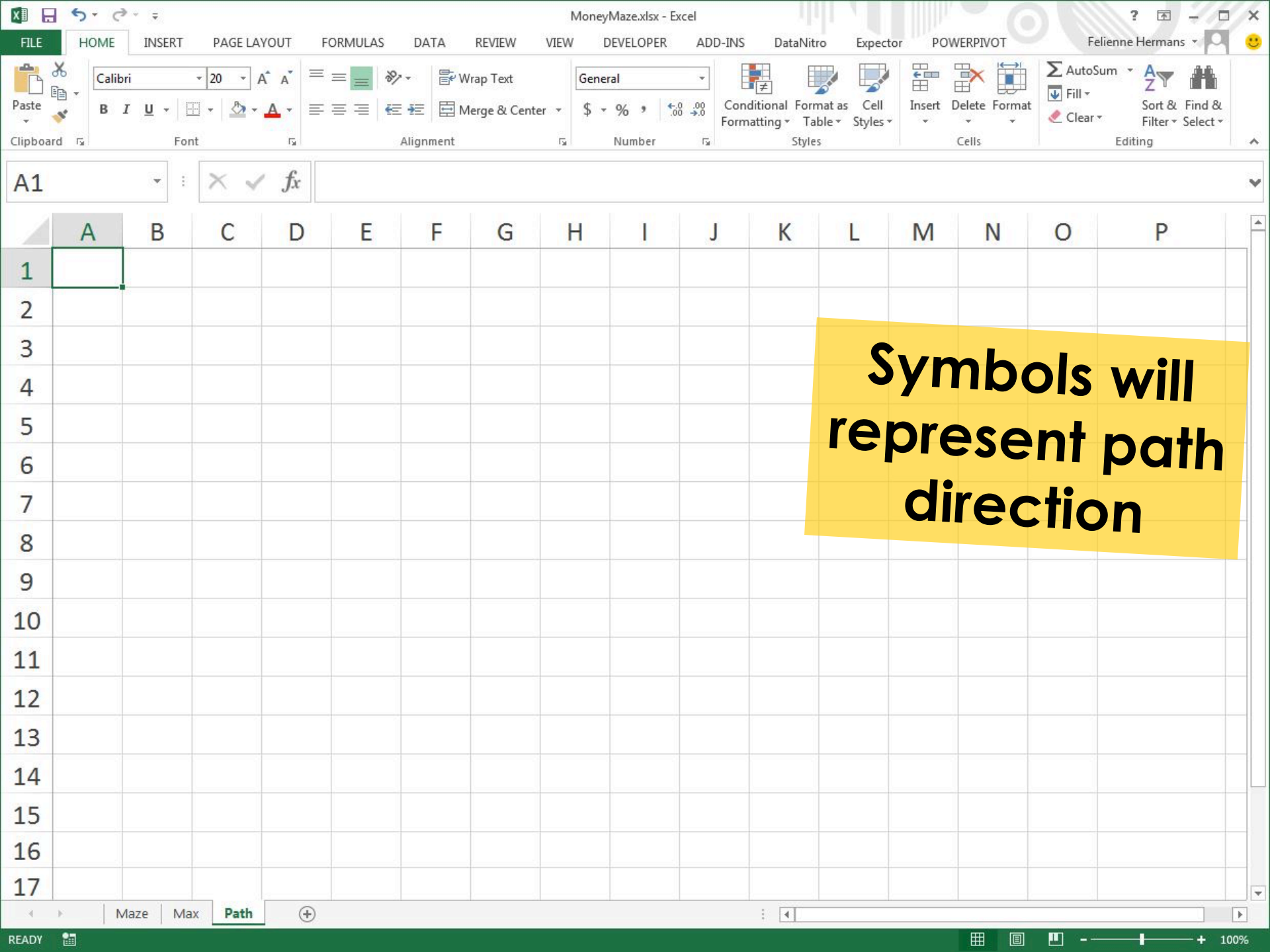
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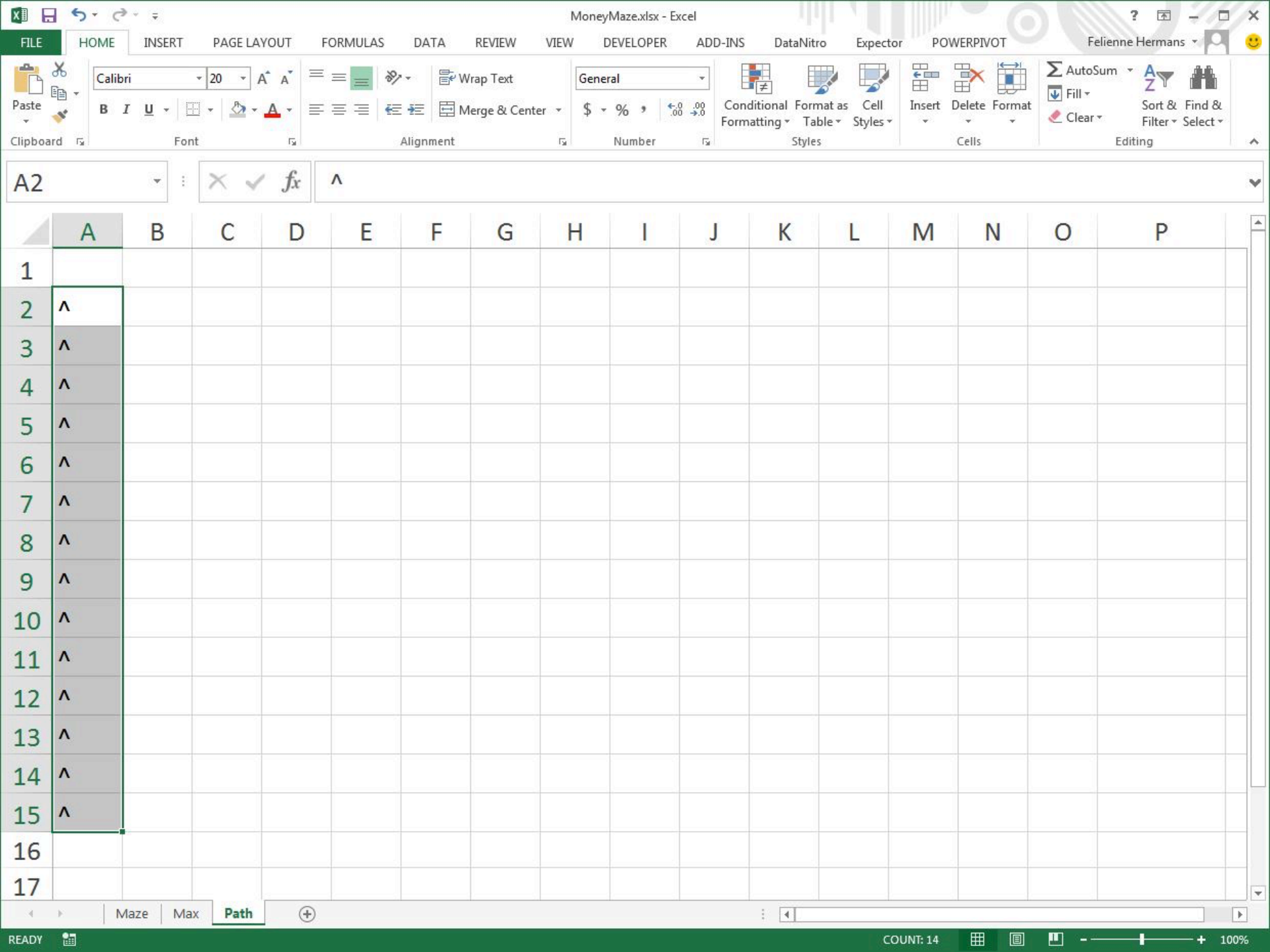
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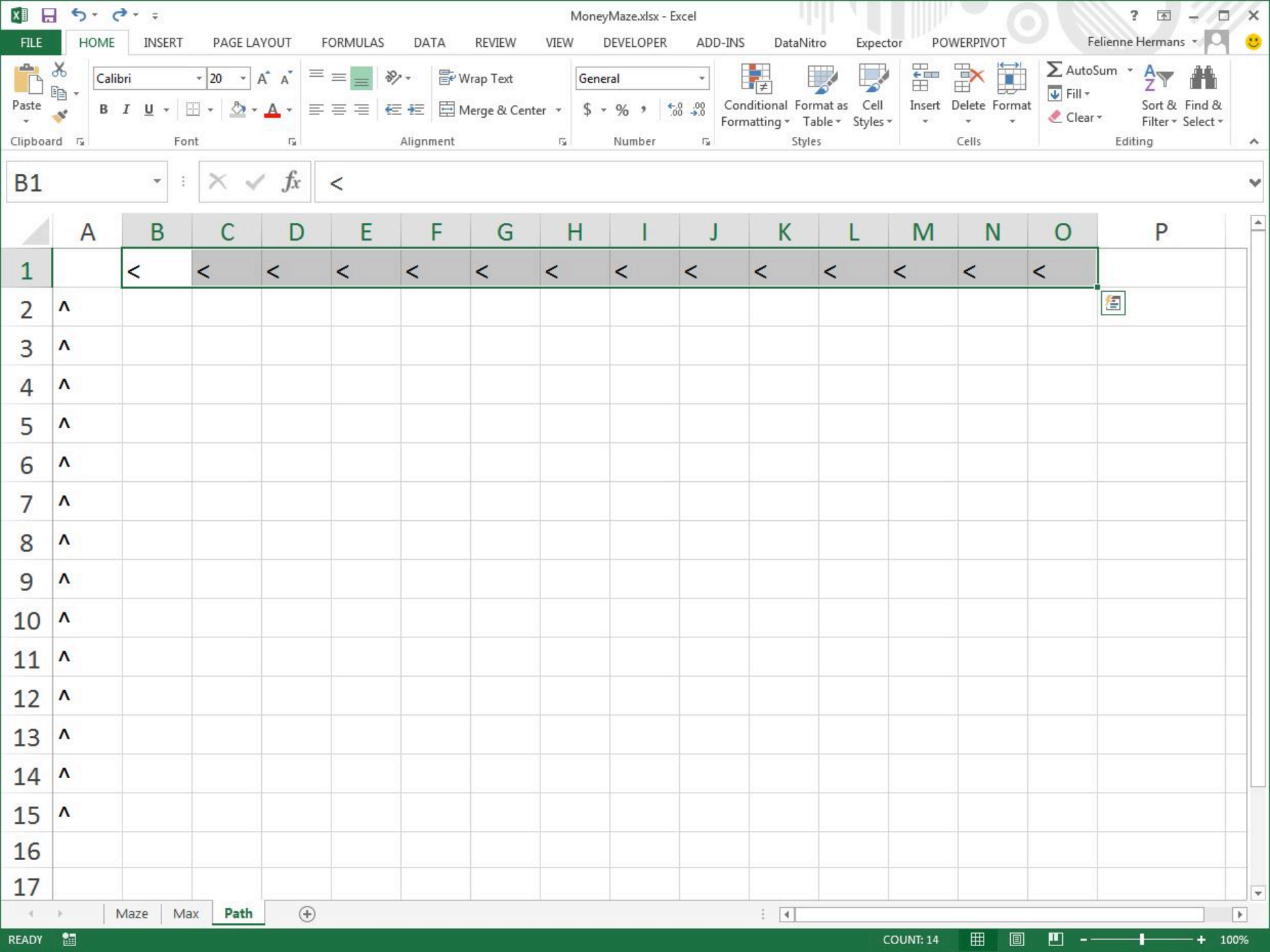
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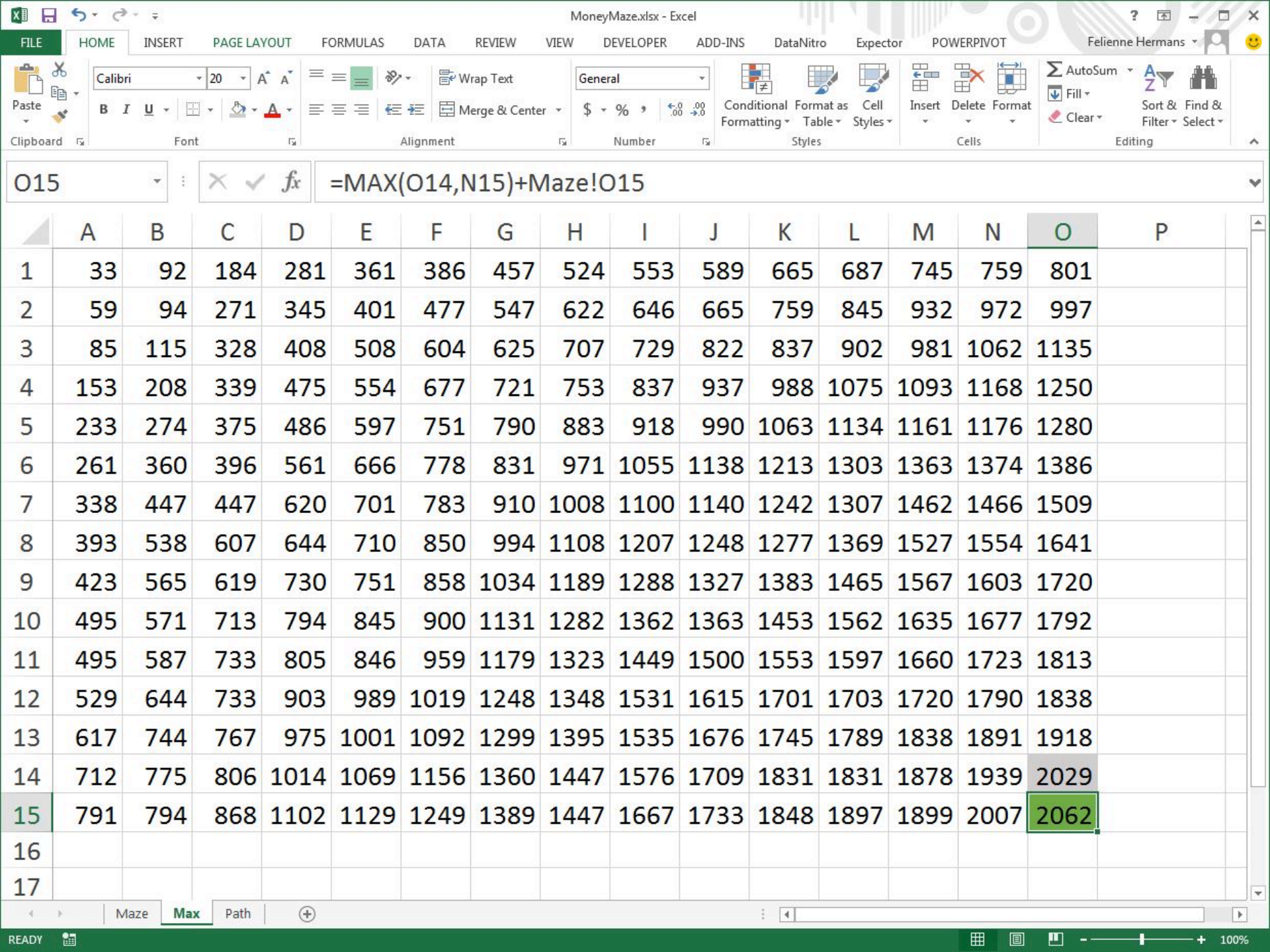

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6	261	360	396	561	666	778	831	971	1055	1138	1213	1303	1363	1374	1386	
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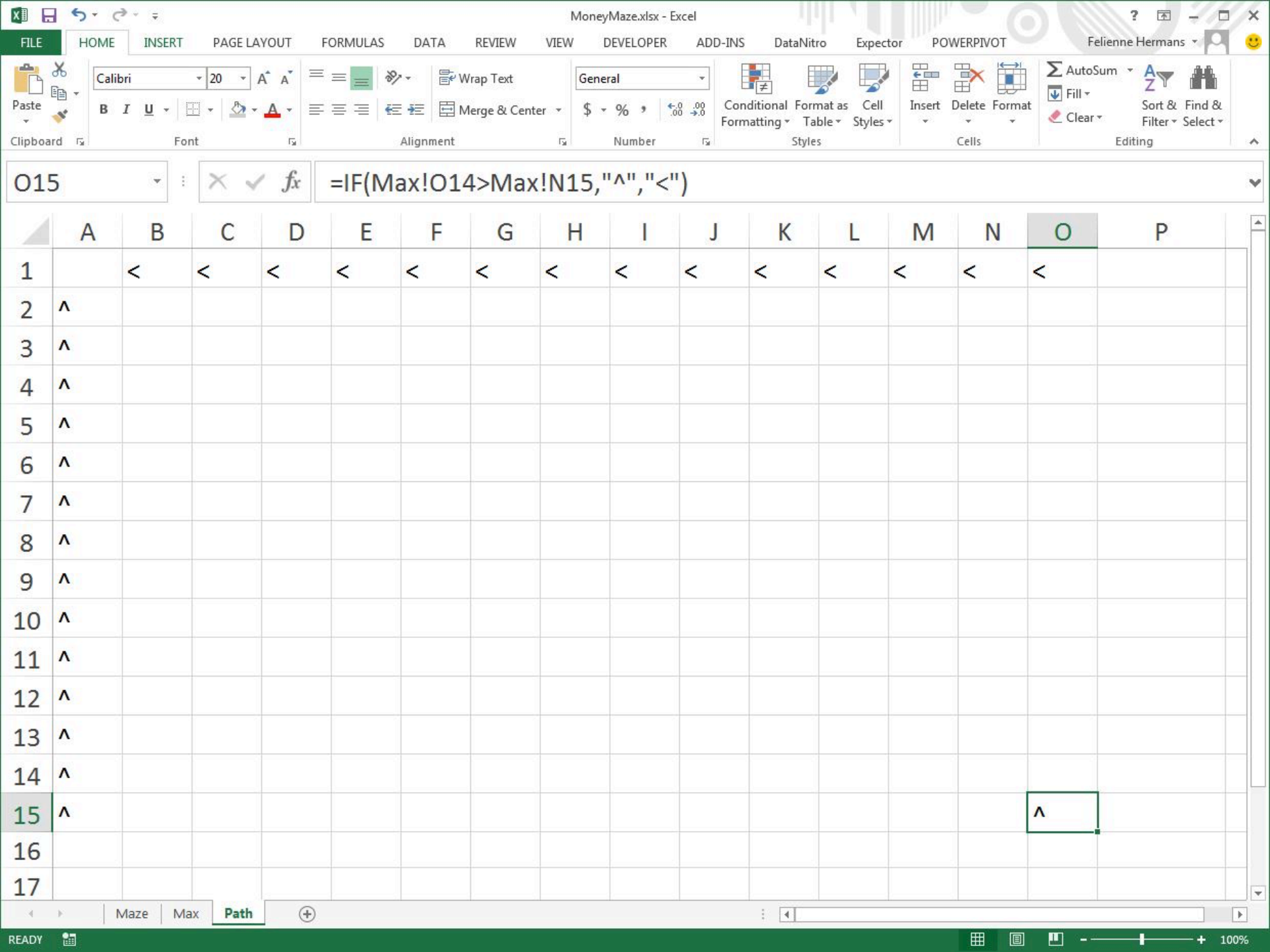
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O15
=IF(Max!O14>Max!N15,"^","<")
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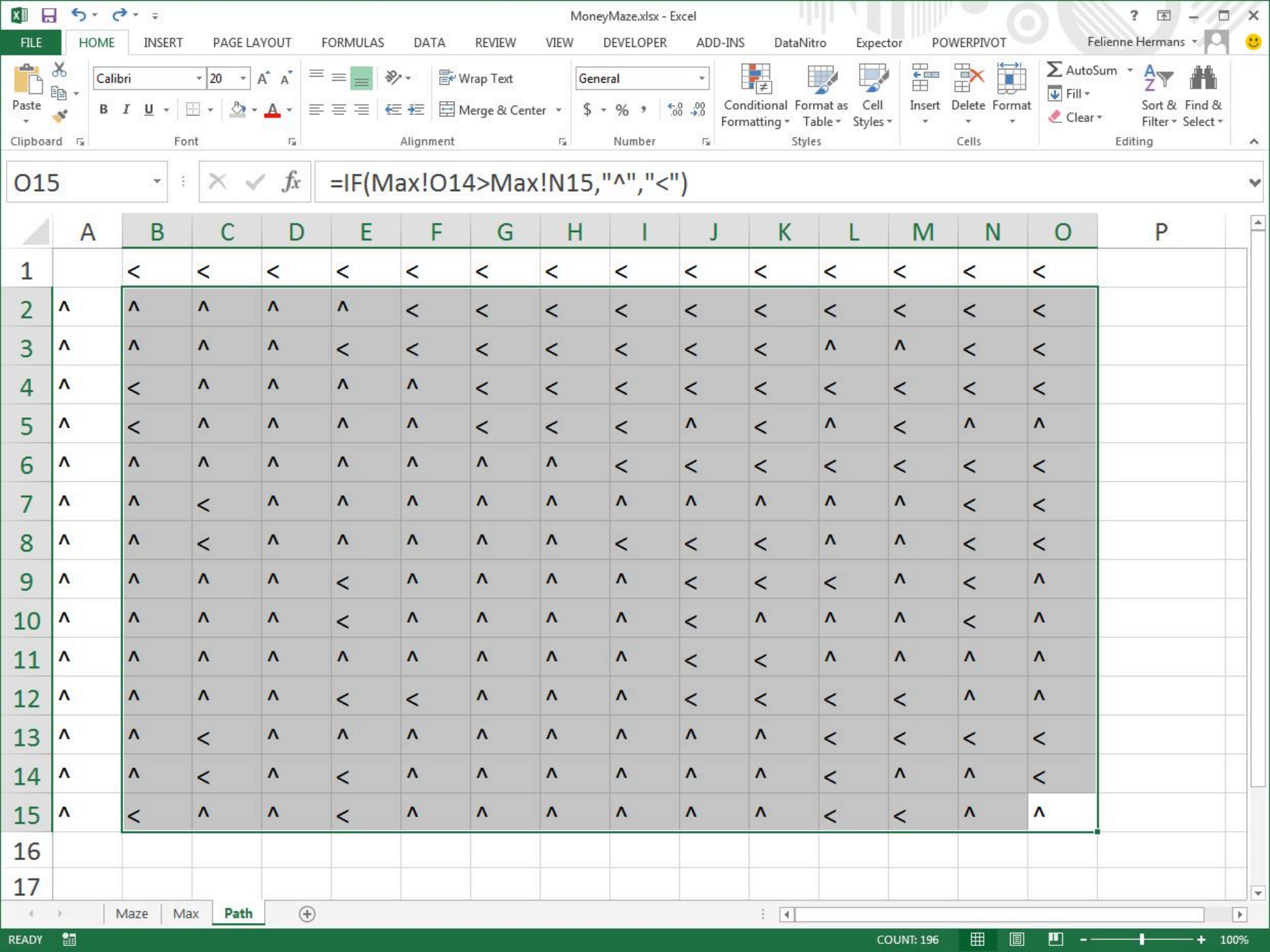

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2	^	^	^	^	^	<	<	<	<	<	<	<	<	<	<	
3	^	^	^	^	<	<	<	<	<	<	<	^	^	<	<	
4	^	<	^	^	^	^	<	<	<	<	<	<	<	<	<	
5	^	<	^	^	^	^	<	<	<	^	<	^	<	^	^	
6	^	^	^	^	^	^	^	^	<	<	<	<	<	<	<	
7	^	^	<	^	^	^	^	^	^	^	^	^	^	<	<	
8	^	^	<	^	^	^	^	^	<	<	<	^	^	<	<	
9	^	^	^	^	<	^	^	^	^	<	<	<	^	<	^	
10	^	^	^	^	<	^	^	^	^	<	^	^	^	<	^	
11	^	^	^	^	^	^	^	^	^	<	<	^	^	^	^	
12	^	^	^	^	<	<	^	^	^	<	<	<	<	^	^	
13	^	^	<	^	^	^	^	^	^	^	^	<	<	<	<	
14	^	^	<	^	<	^	^	^	^	^	^	<	^	^	<	
15	^	<	^	^	<	^	^	^	^	^	^	<	<	^	^	
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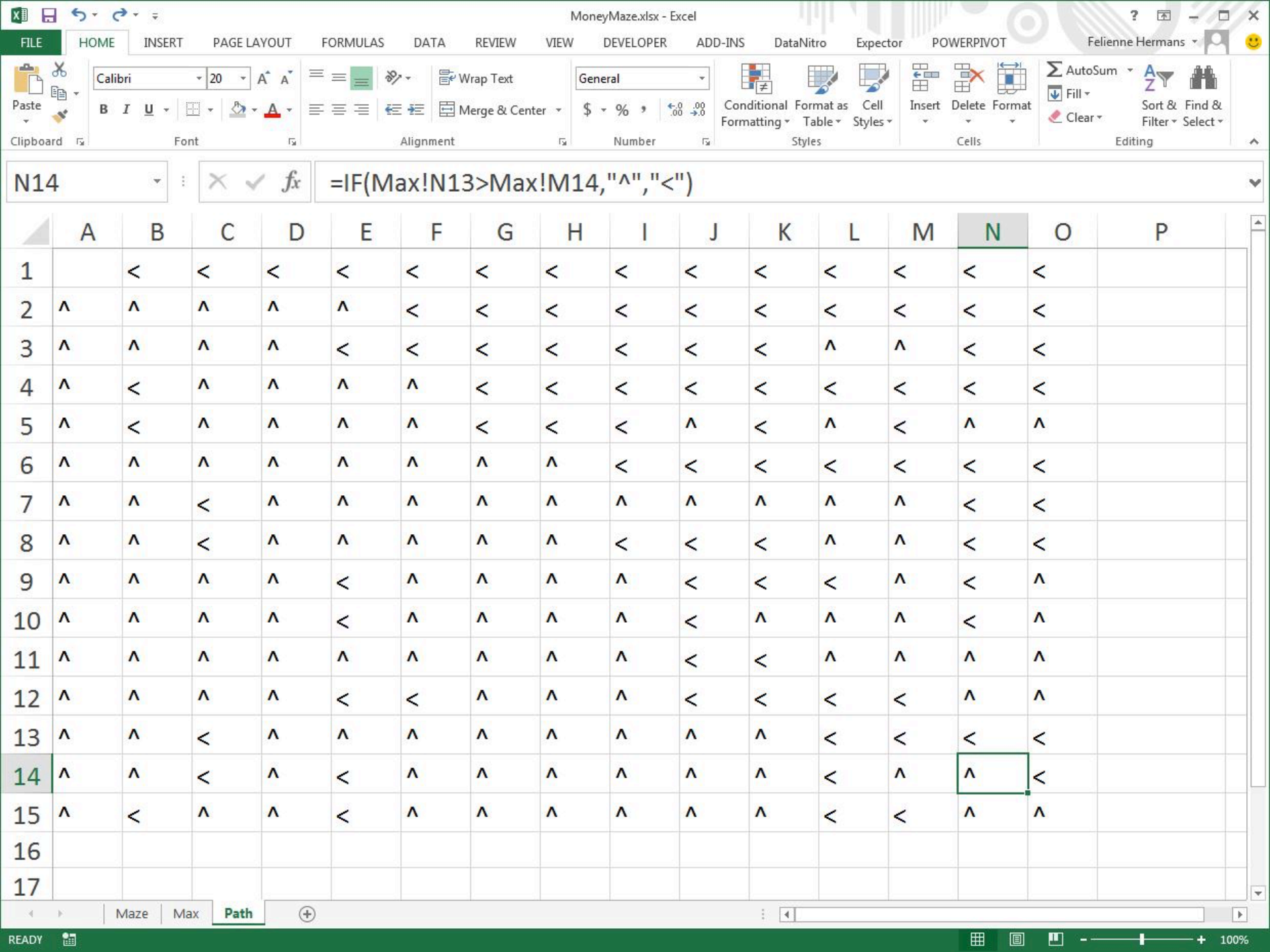

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
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3	^	^	^	^	<	<	<	<	<	<	<	^	^	<	<	
4	^	<	^	^	^	^	<	<	<	<	<	<	<	<	<	
5	^	<	^	^	^	^	<	<	<	^	<	^	<	^	^	
6	^	^	^	^	^	^	^	^	<	<	<	<	<	<	<	
7	^	^	<	^	^	^	^	^	^	^	^	^	^	<	<	
8	^	^	<	^	^	^	^	^	<	<	<	^	^	<	<	
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10	^	^	^	^	<	^	^	^	^	<	^	^	^	<	^	
11	^	^	^	^	^	^	^	^	^	<	<	^	^	^	^	
12	^	^	^	^	<	<	^	^	^	<	<	<	<	^	^	
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14	^	^	<	^	<	^	^	^	^	^	^	<	^	^	<	
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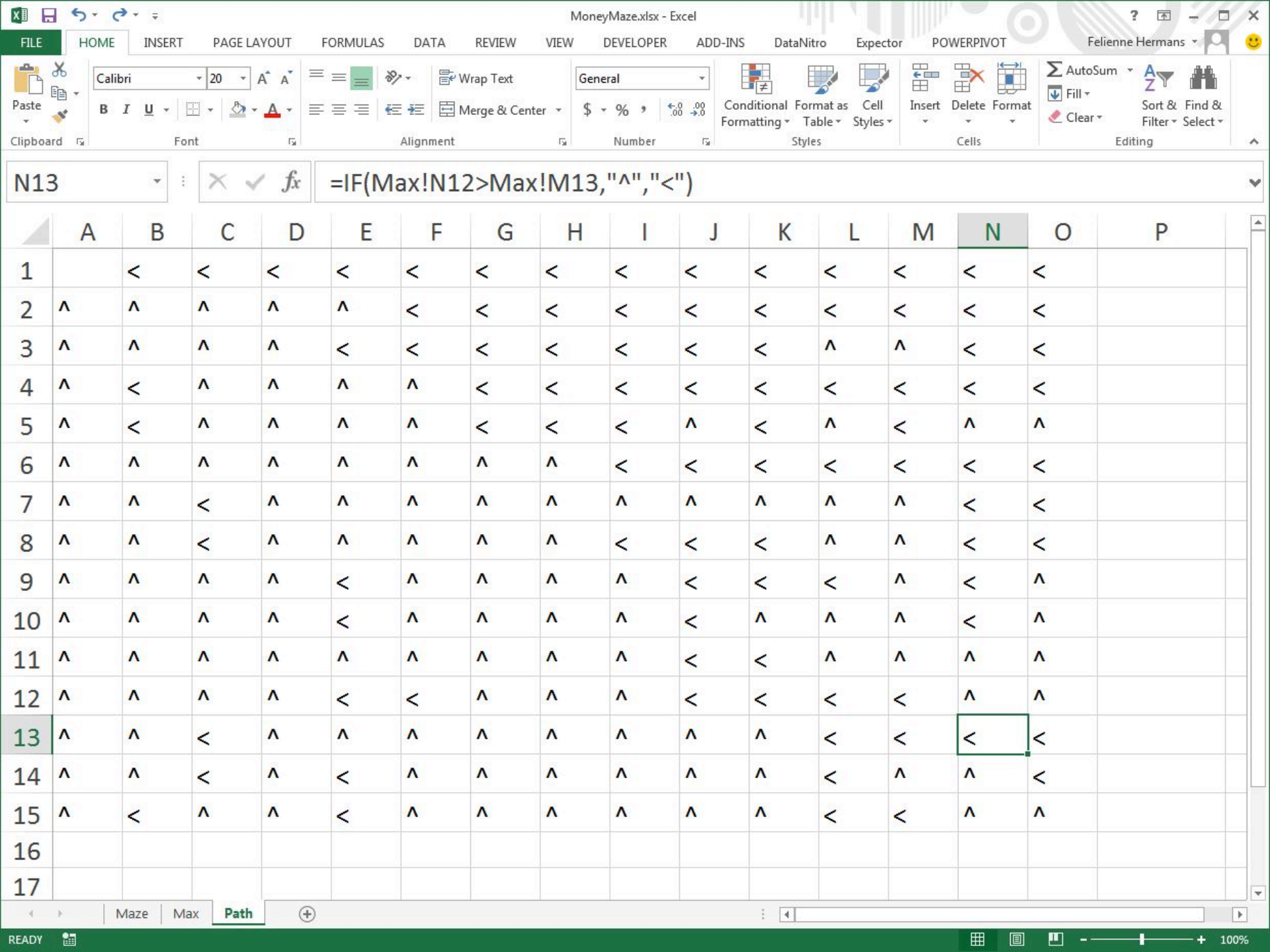

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6	^	^	^	^	^	^	^	^	<	<	<	<	<	<	<	
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9	^	^	^	^	<	^	^	^	^	<	<	<	^	<	^	
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11	^	^	^	^	^	^	^	^	^	<	<	^	^	^	^	
12	^	^	^	^	<	<	^	^	^	<	<	<	<	^	^	
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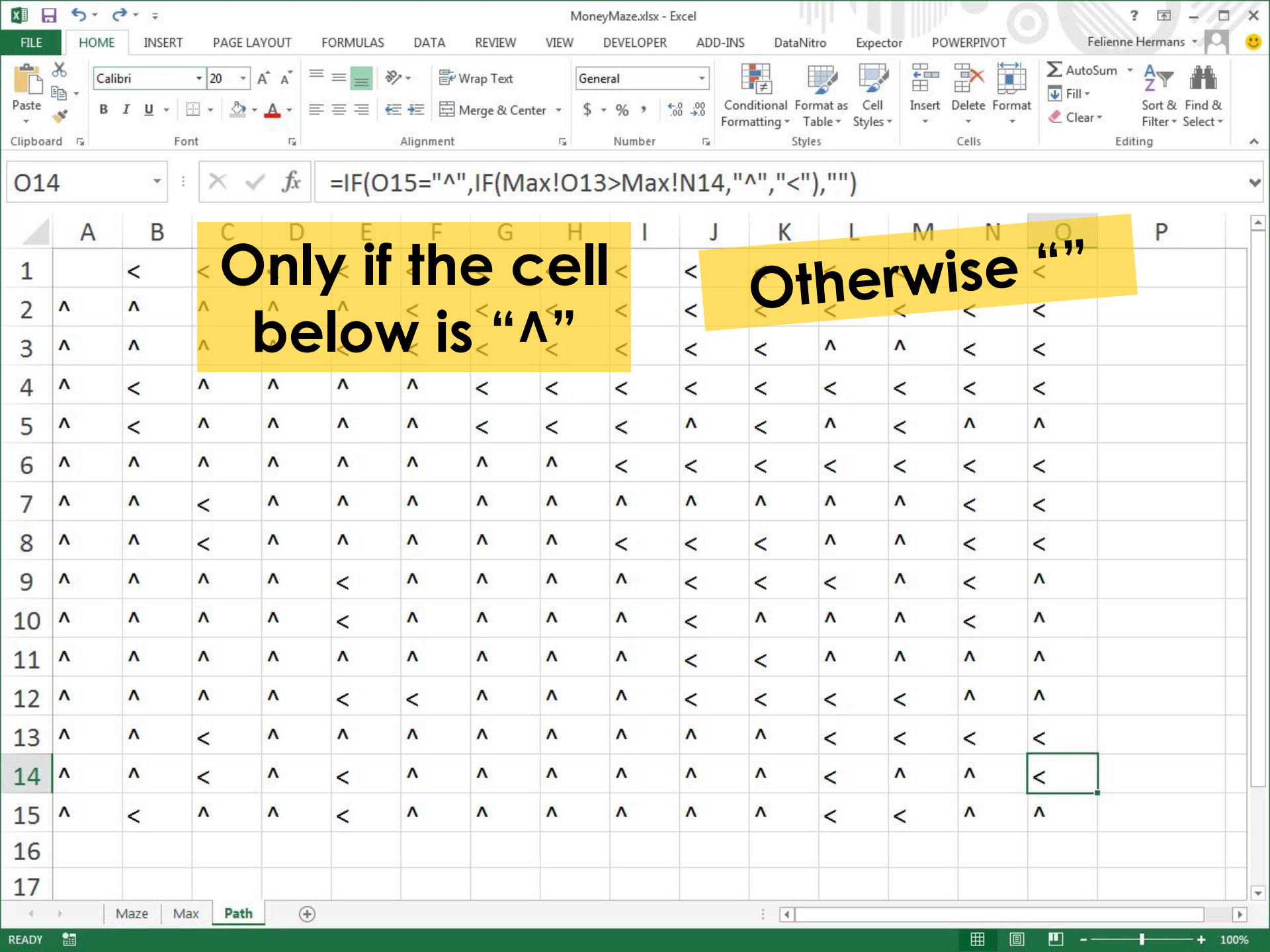
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O14
=IF(O15="^",IF(Max!O13>Max!N14,"^","<"),"")
Only if the cell below is "^"
Otherwise ""
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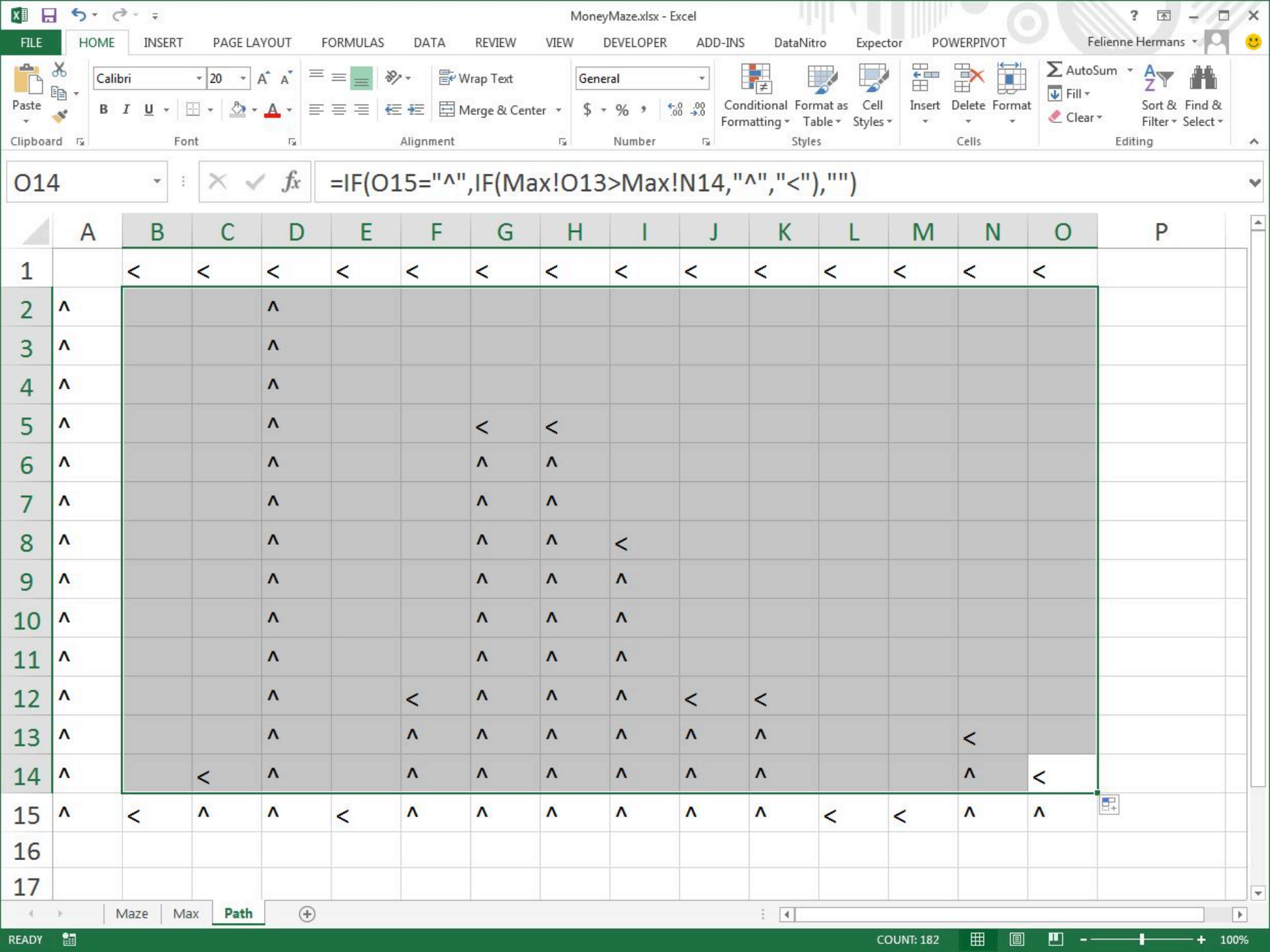
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O14
=IF(O15="^",IF(Max!O13>Max!N14,"^","<"),"")
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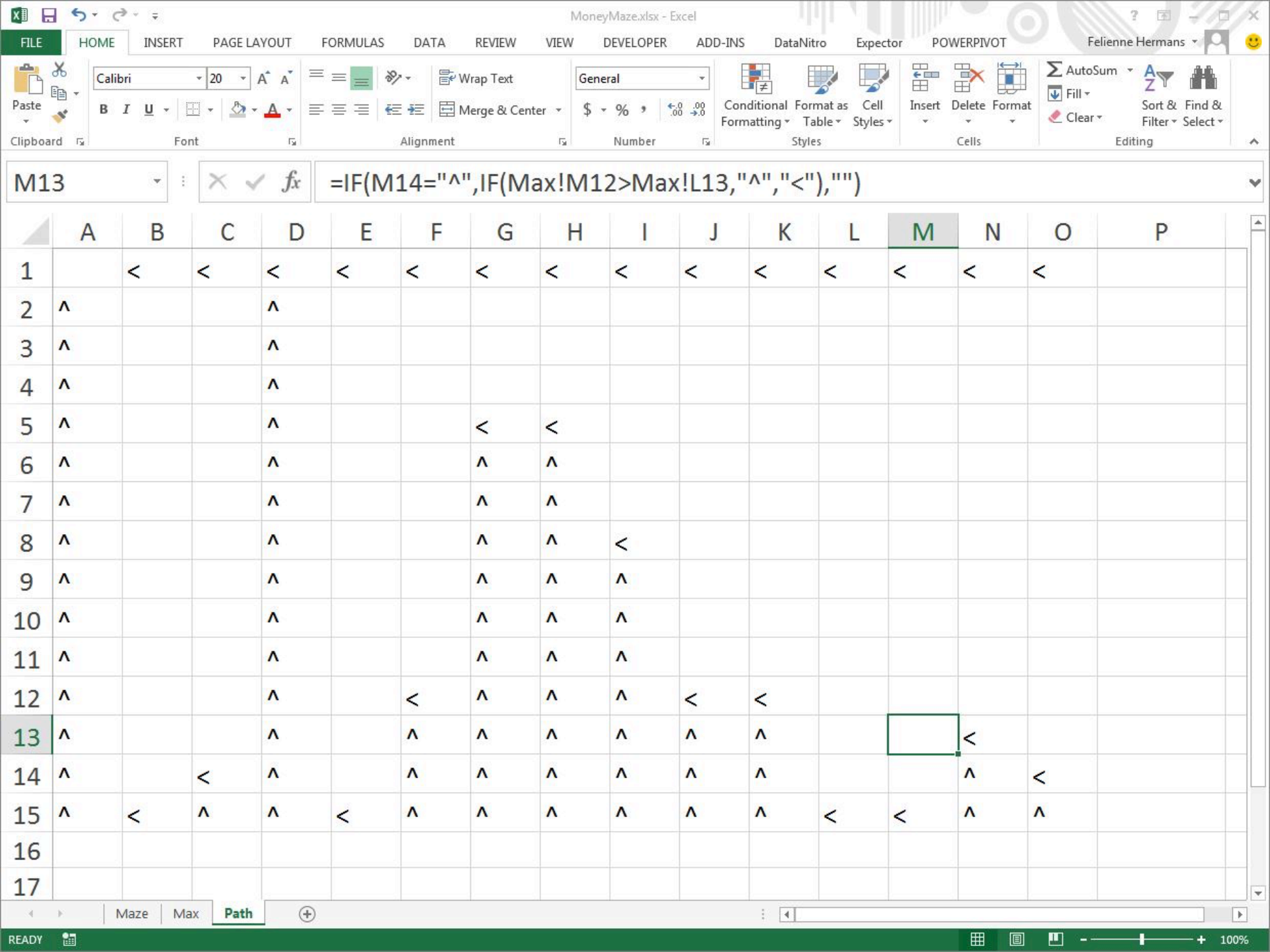

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
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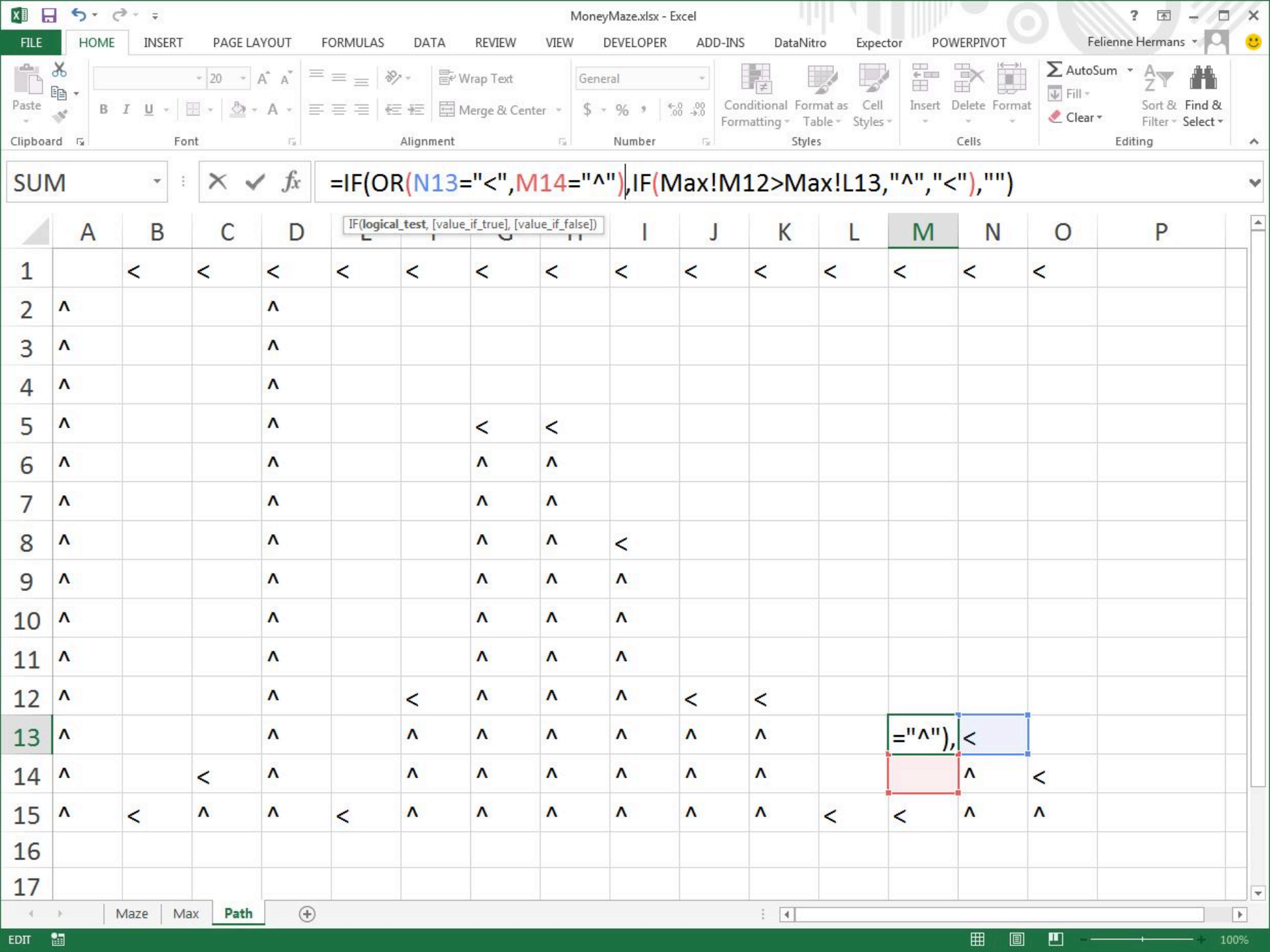
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SUM
=IF(OR(N13="<",M14="^"),IF(Max!M12>Max!L13,"^","<"),"")
IF(logical_test, [value_if_true], [value_if_false])
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13 ^ ^ ^ ^ ^ ^ ="^"),<
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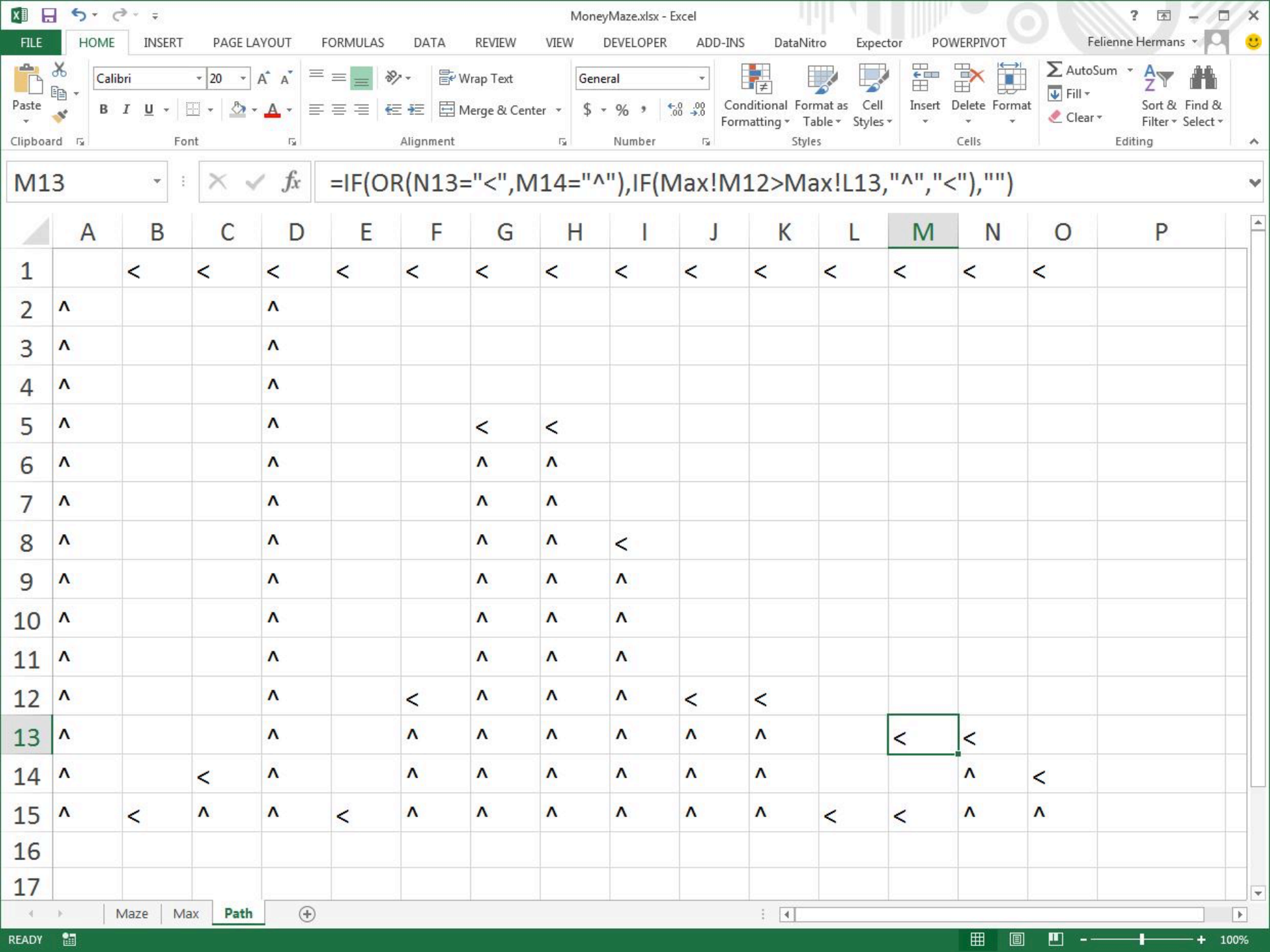

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11	^			^			^	^	^							
12	^			^		<	^	^	^	<	<					
13	^			^		^	^	^	^	^	^		<	<		
14	^		<	^		^	^	^	^	^	^			^	<	
15	^	<	^	^	<	^	^	^	^	^	^	<	<	^	^	
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N15 =IF(OR(O15="<",N16="^"),IF(Max!N14>Max!M15,"^","<"),"")

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
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3	^			^	<	<										
4	^					^										
5	^					^	<	<								
6	^							^								
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12	^								^	<	<					
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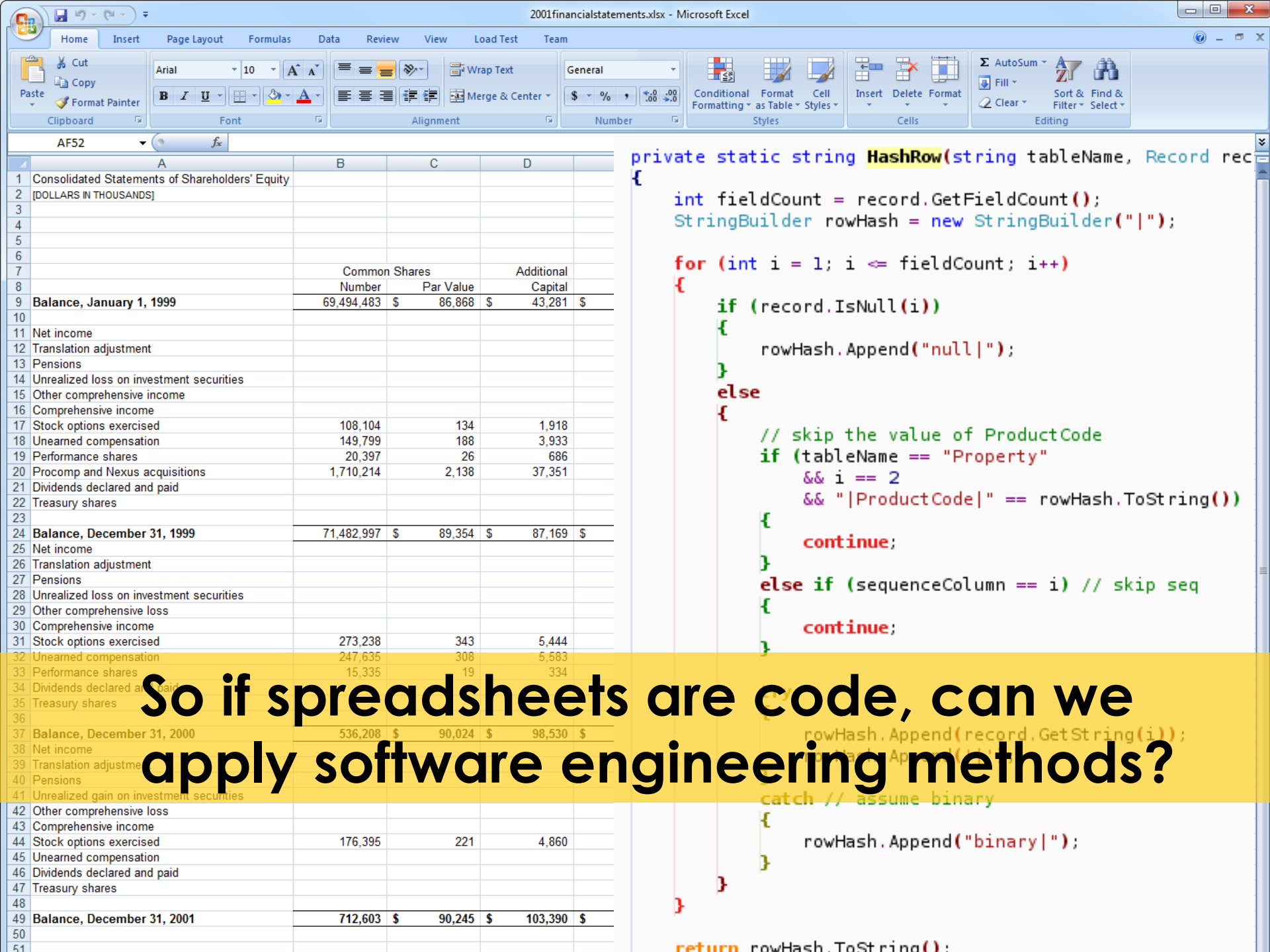
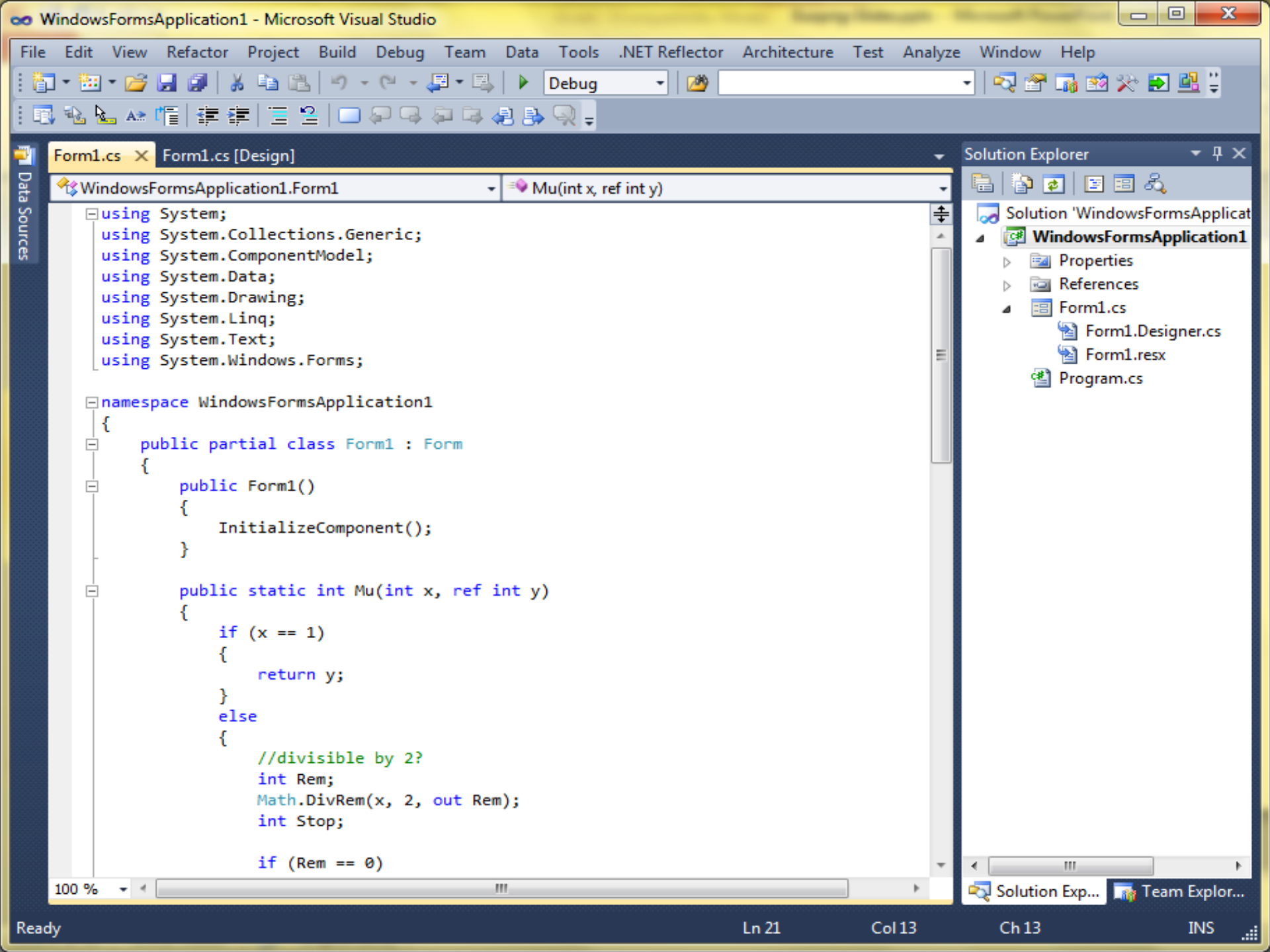
Spreadsheets are code



So if spreadsheets are code, can we apply software engineering methods?

In software, tools have been created to help programmers understand code


WindowsFormsApplication1 - Microsoft Visual Studio
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WindowsFormsApplication1.Form1
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using System;
using System.Collections.Generic;
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using System.Data;
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}
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int Rem;
Math.DivRem(x, 2, out Rem);
int Stop;
if (Rem == 0)
100 %
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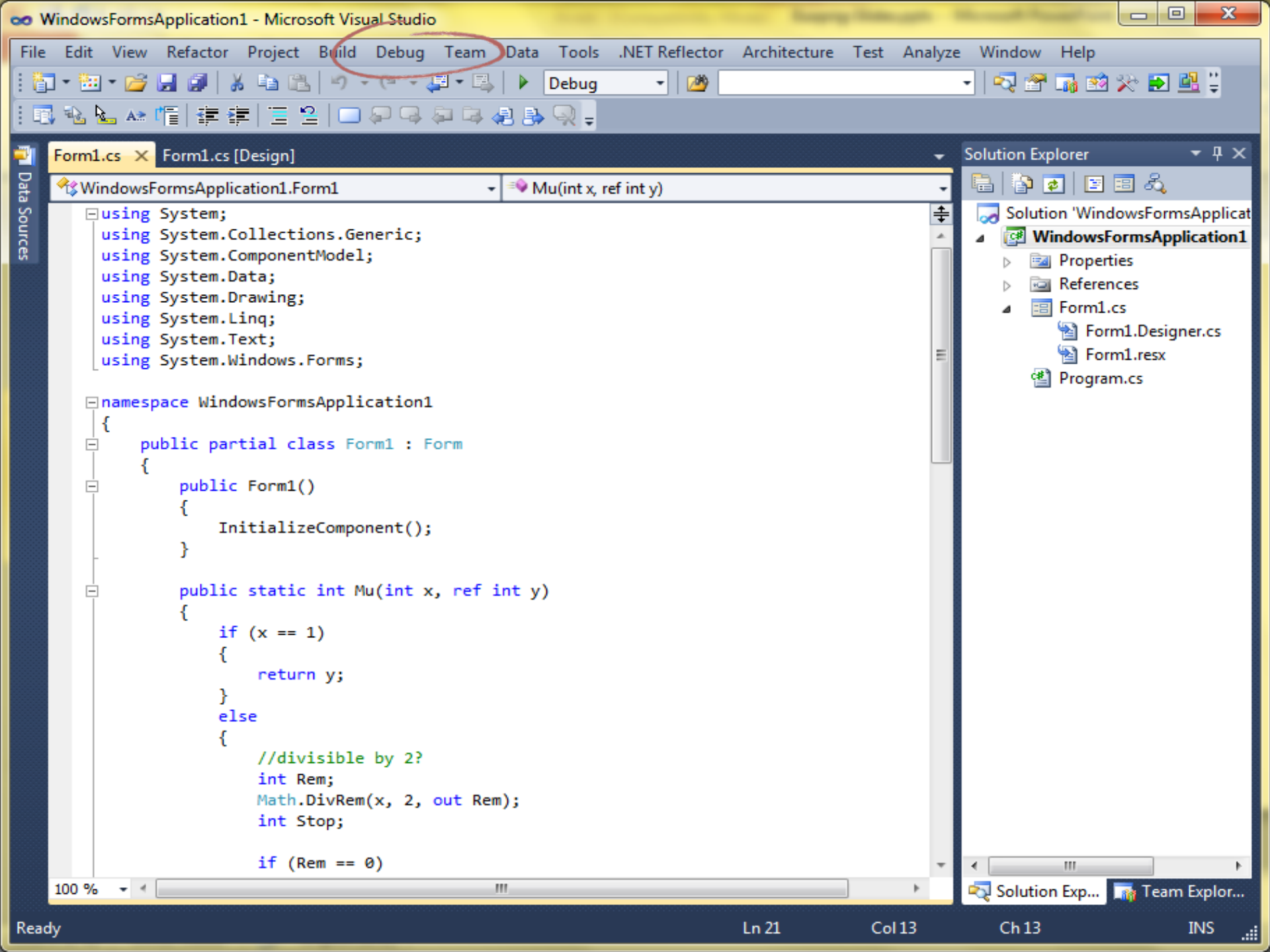
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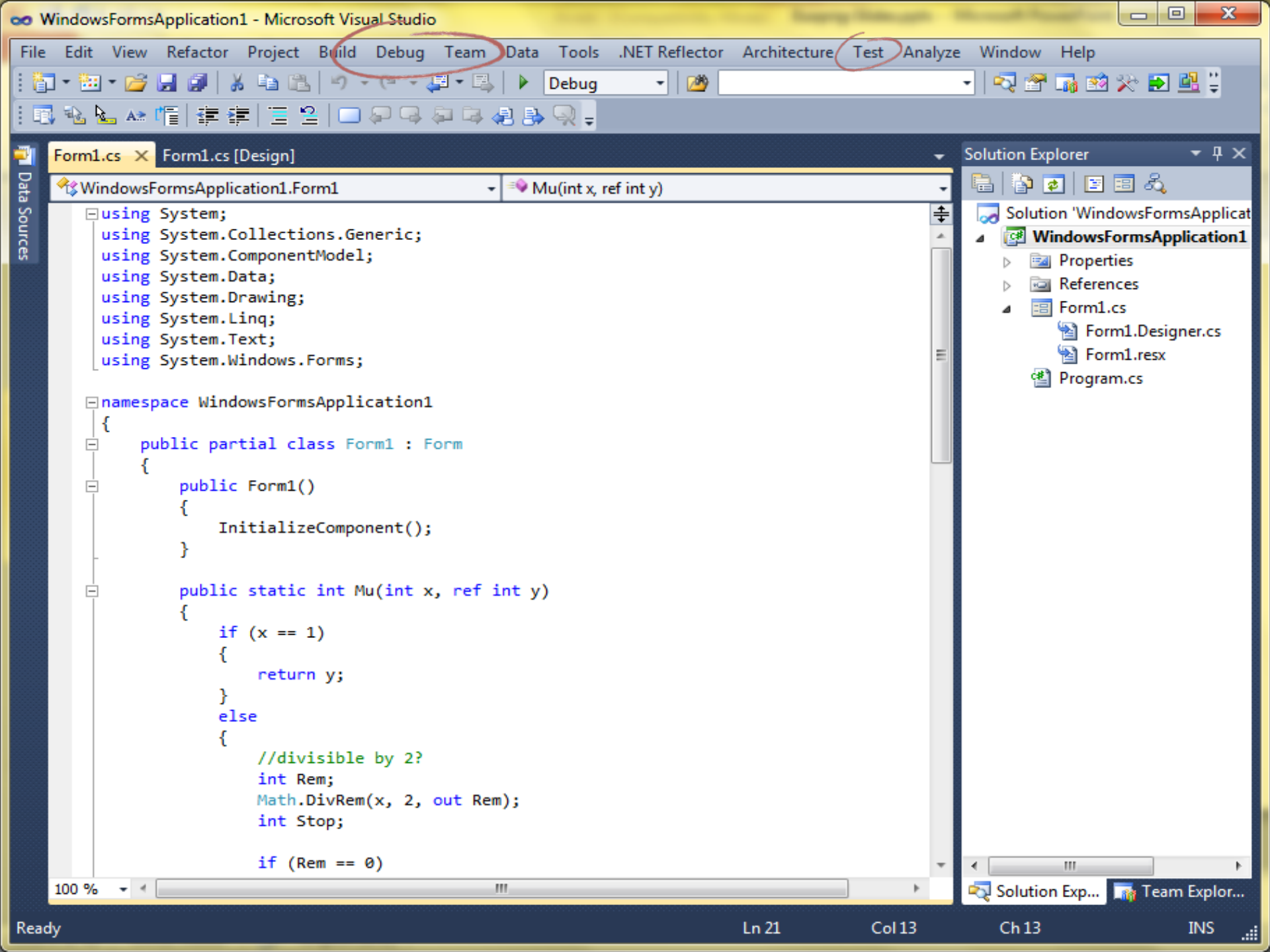
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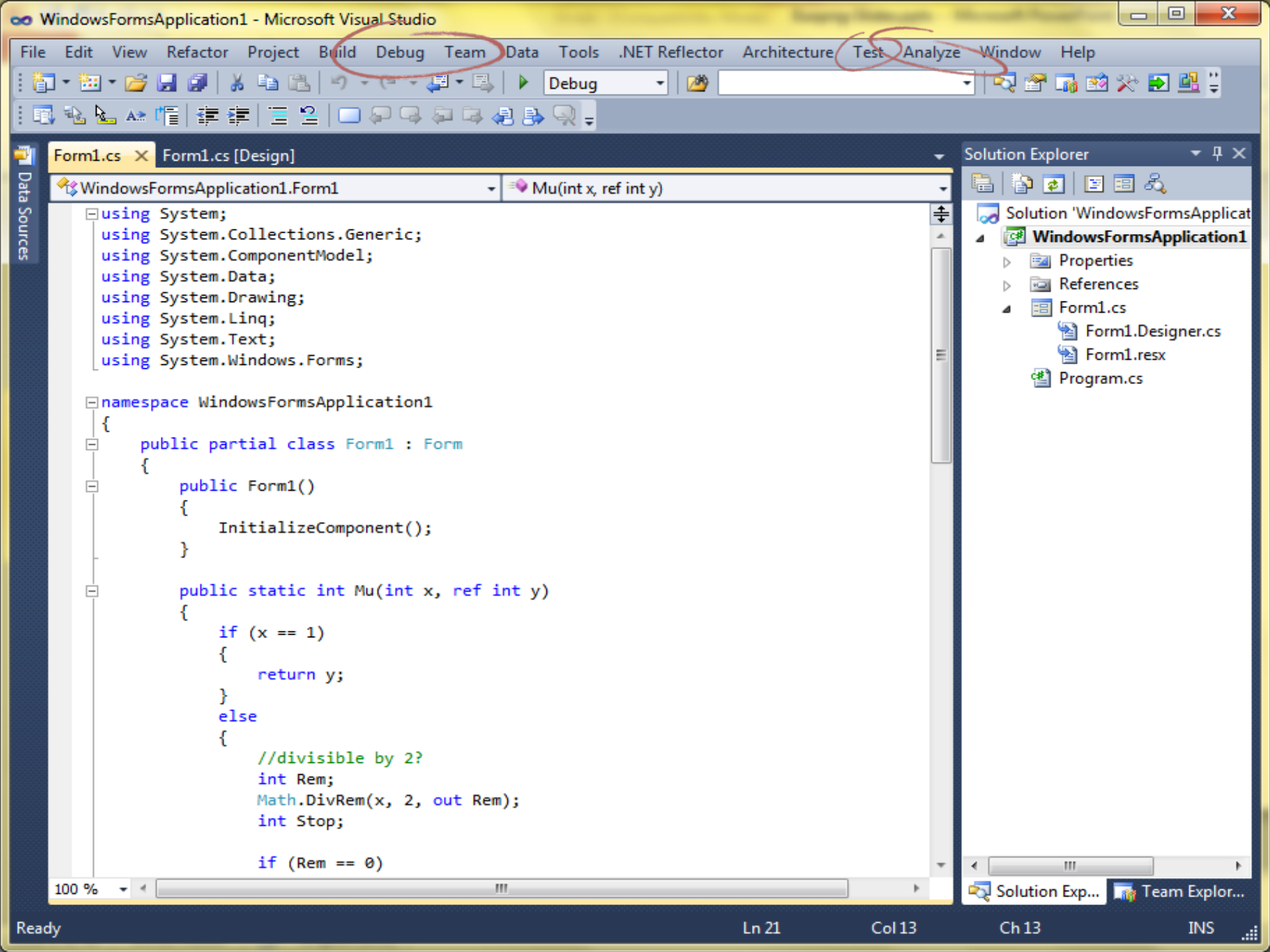
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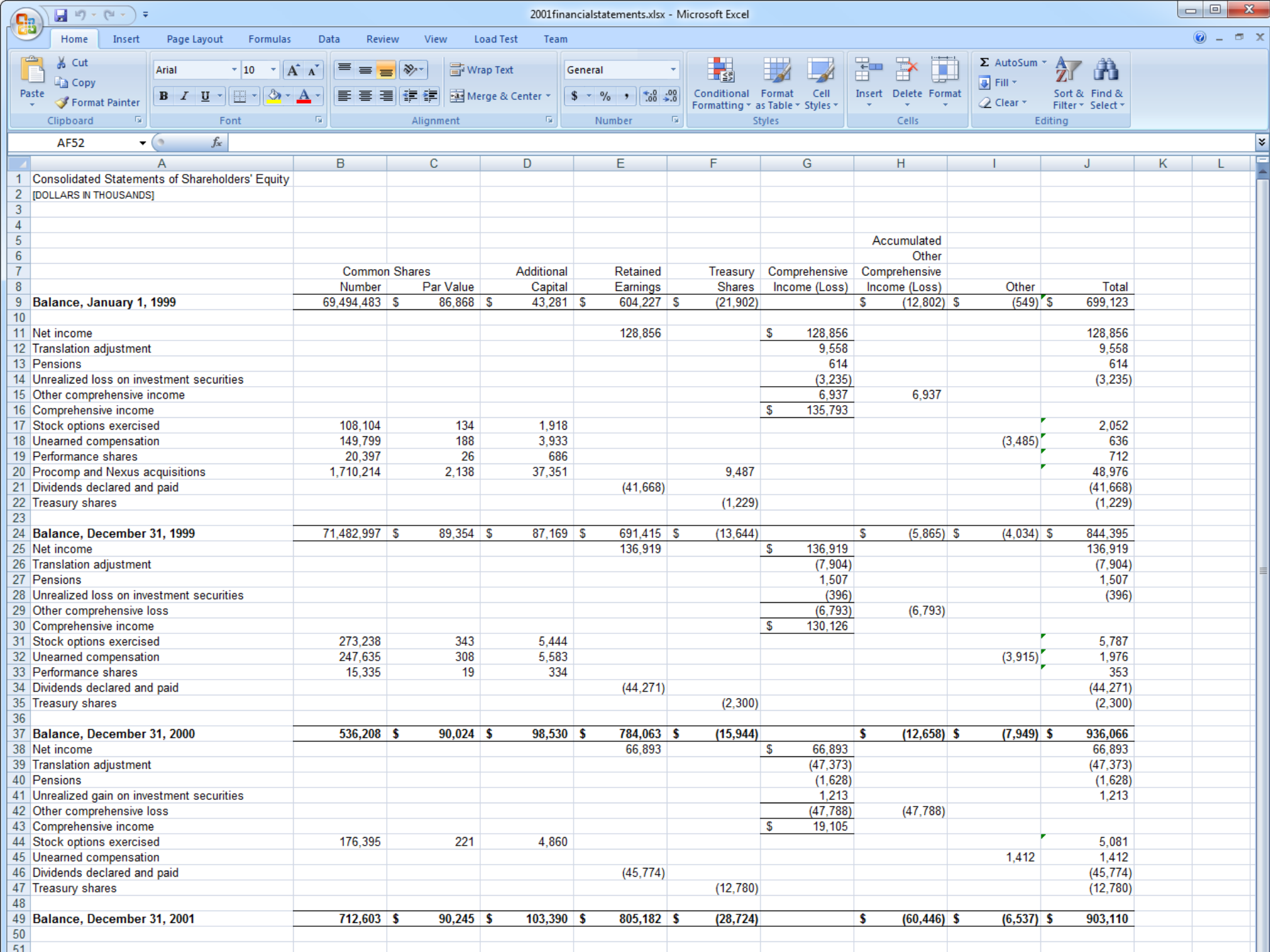

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1	Consolidated Statements of Shareholders' Equity											
2	[DOLLARS IN THOUSANDS]											
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5								Accumulated				
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11	Net income				128,856		$ 128,856			128,856		
12	Translation adjustment						9,558			9,558		
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14	Unrealized loss on investment securities						(3,235)			(3,235)		
15	Other comprehensive income						6,937	6,937				
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17	Stock options exercised	108,104	134	1,918						2,052		
18	Unearned compensation	149,799	188	3,933					(3,485)	636		
19	Performance shares	20,397	26	686						712		
20	Procomp and Nexus acquisitions	1,710,214	2,138	37,351		9,487				48,976		
21	Dividends declared and paid				(41,668)					(41,668)		
22	Treasury shares					(1,229)				(1,229)		
23												
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25	Net income				136,919		$ 136,919			136,919		
26	Translation adjustment						(7,904)			(7,904)		
27	Pensions						1,507			1,507		
28	Unrealized loss on investment securities						(396)			(396)		
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37	**Balance, December 31, 2000**	**536,208**	**$ 90,024**	**$ 98,530**	**$ 784,063**	**$ (15,944)**		**$ (12,658)**	**$ (7,949)**	**$ 936,066**		
38	Net income				66,893		$ 66,893			66,893		
39	Translation adjustment						(47,373)			(47,373)		
40	Pensions						(1,628)			(1,628)		
41	Unrealized gain on investment securities						1,213			1,213		
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44	Stock options exercised	176,395	221	4,860						5,081		
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47	Treasury shares					(12,780)				(12,780)		
48												
49	**Balance, December 31, 2001**	**712,603**	**$ 90,245**	**$ 103,390**	**$ 805,182**	**$ (28,724)**		**$ (60,446)**	**$ (6,537)**	**$ 903,110**		
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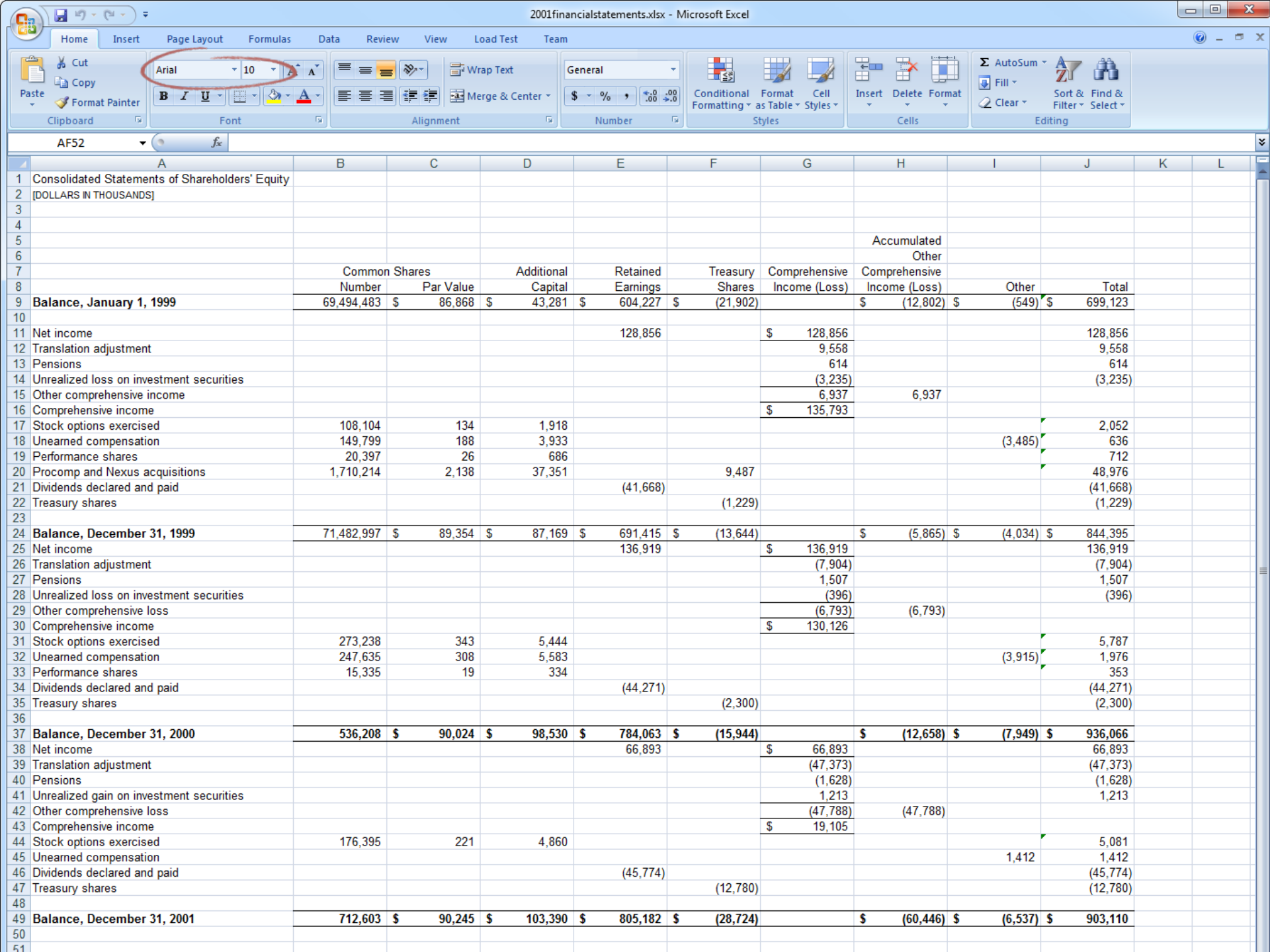

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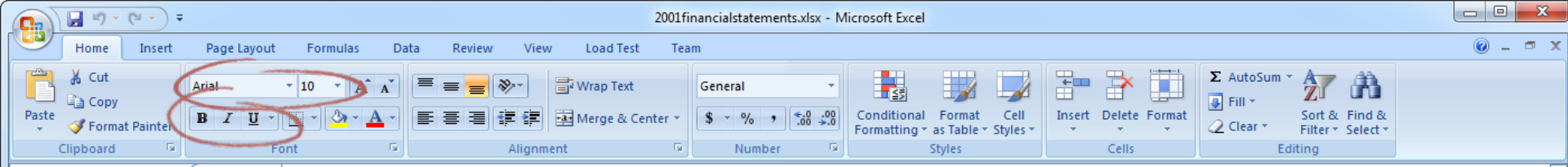

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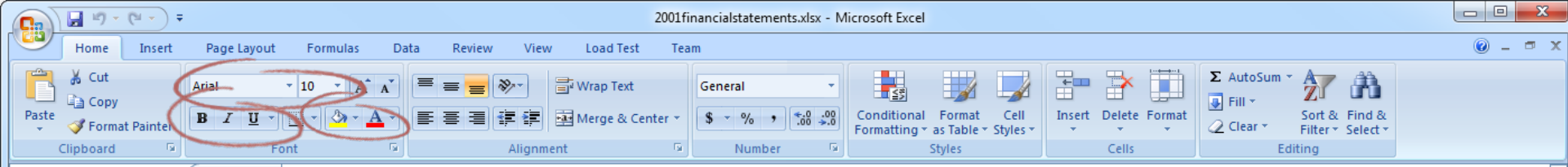

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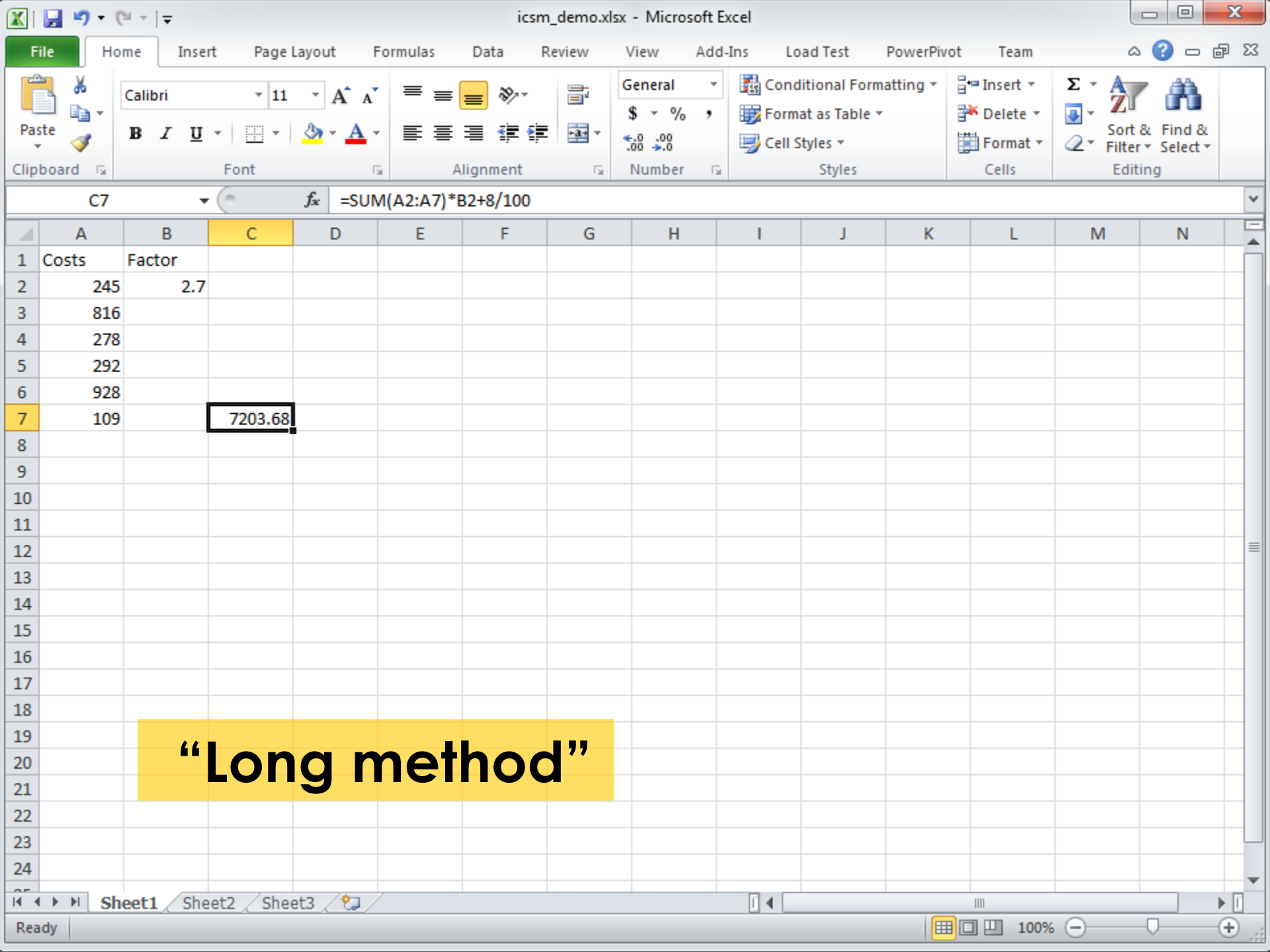
Because spreadsheets are so similar to code, users can benefit from SE methods


Like “code smells”
for spreadsheet
formulas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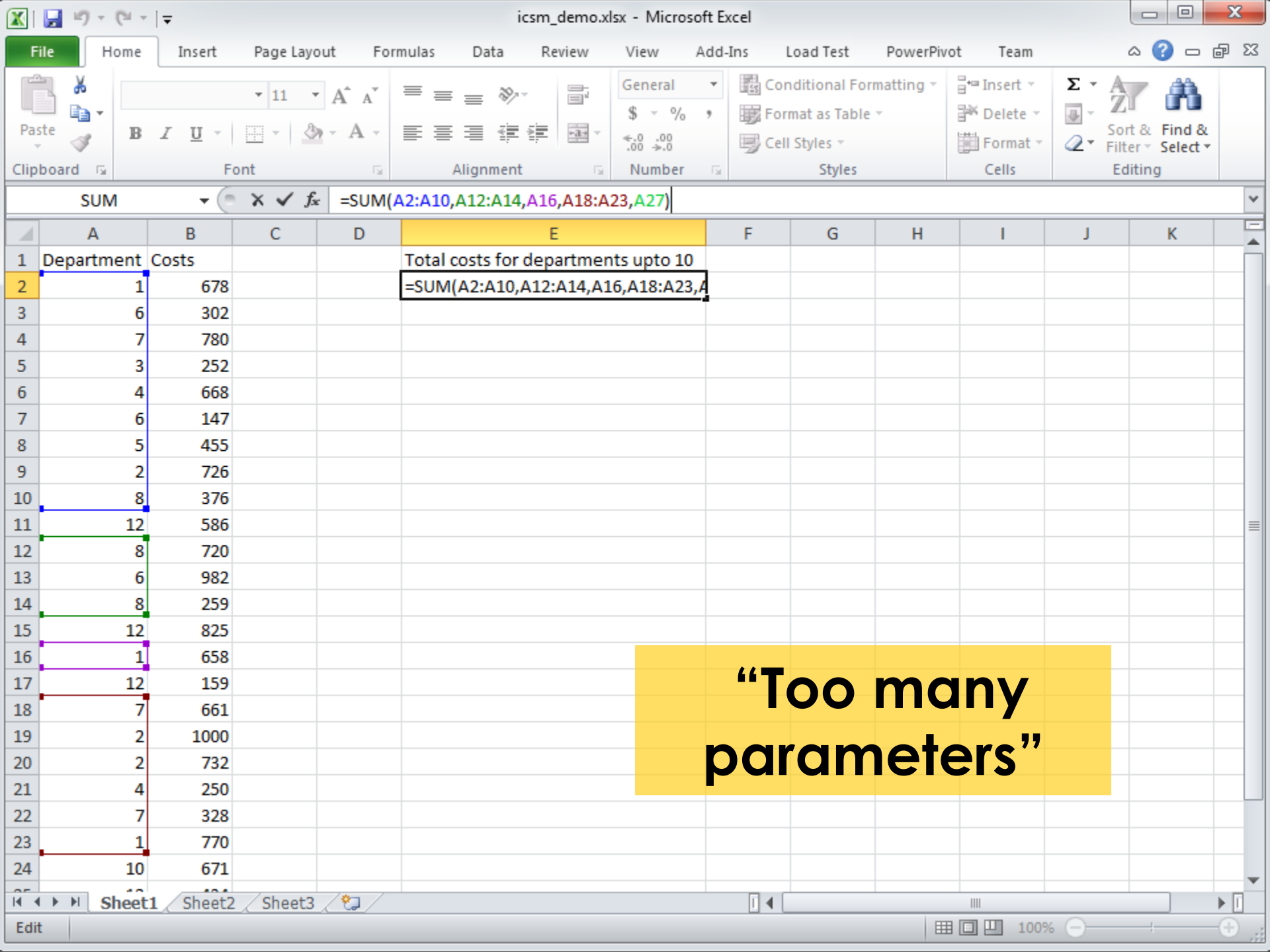
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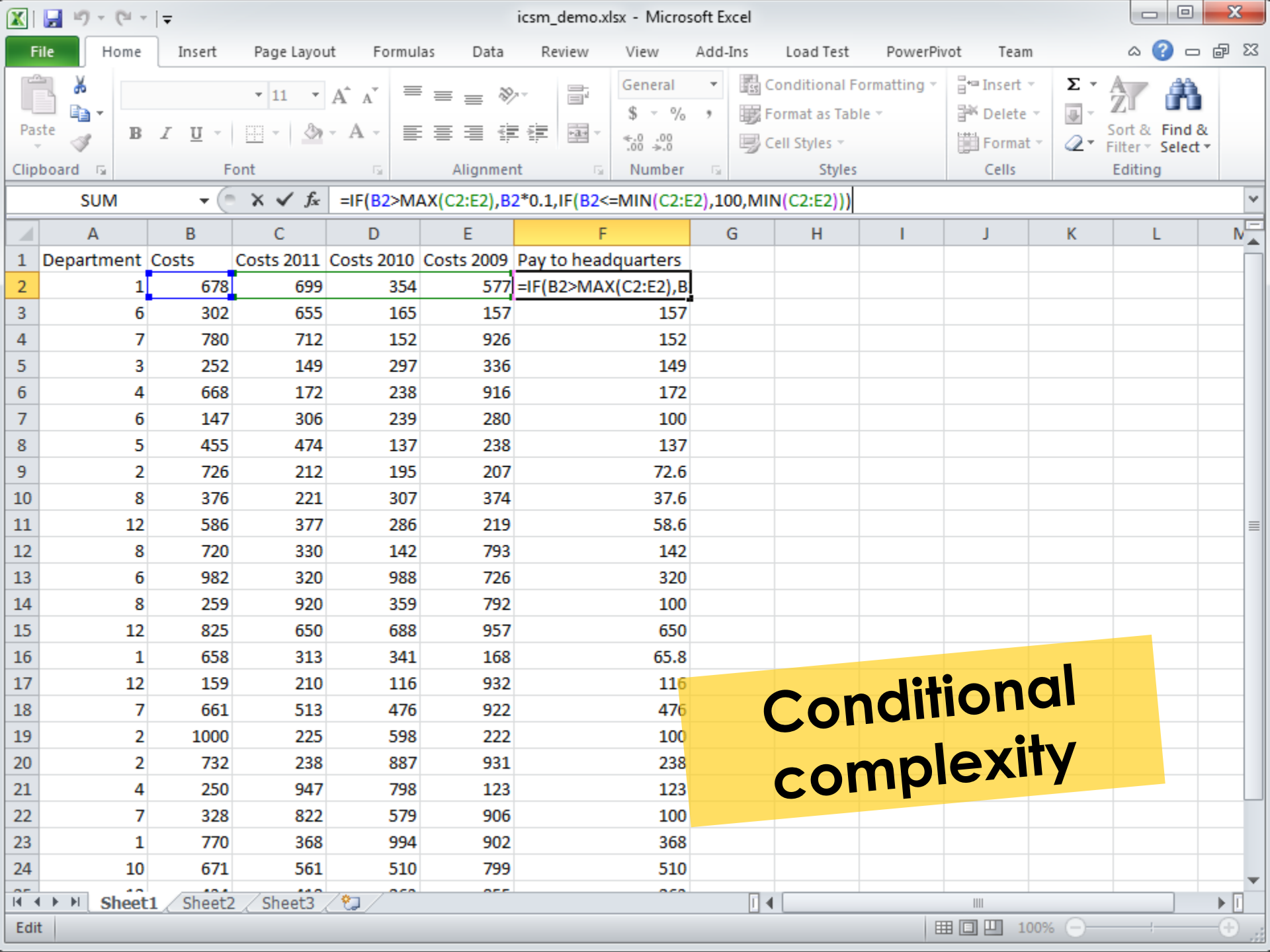
SUM
=SUM(A2:A10,A12:A14,A16,A18:A23,A27)
Total costs for departments upto 10
=SUM(A2:A10,A12:A14,A16,A18:A23,A
Department
Costs
1 678
6 302
7 780
3 252
4 668
6 147
5 455
2 726
8 376
12 586
8 720
6 982
8 259
12 825
1 658
12 159
7 661
2 1000
2 732
4 250
7 328
1 770
10 671
Sheet1
Sheet2
Sheet3
Edit
100%
“Too many parameters”


icsm_demo.xlsx - Microsoft Excel
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Add-Ins
Load Test
PowerPivot
Team
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Clipboard
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Alignment
Number
General
Conditional Formatting
Format as Table
Cell Styles
Styles
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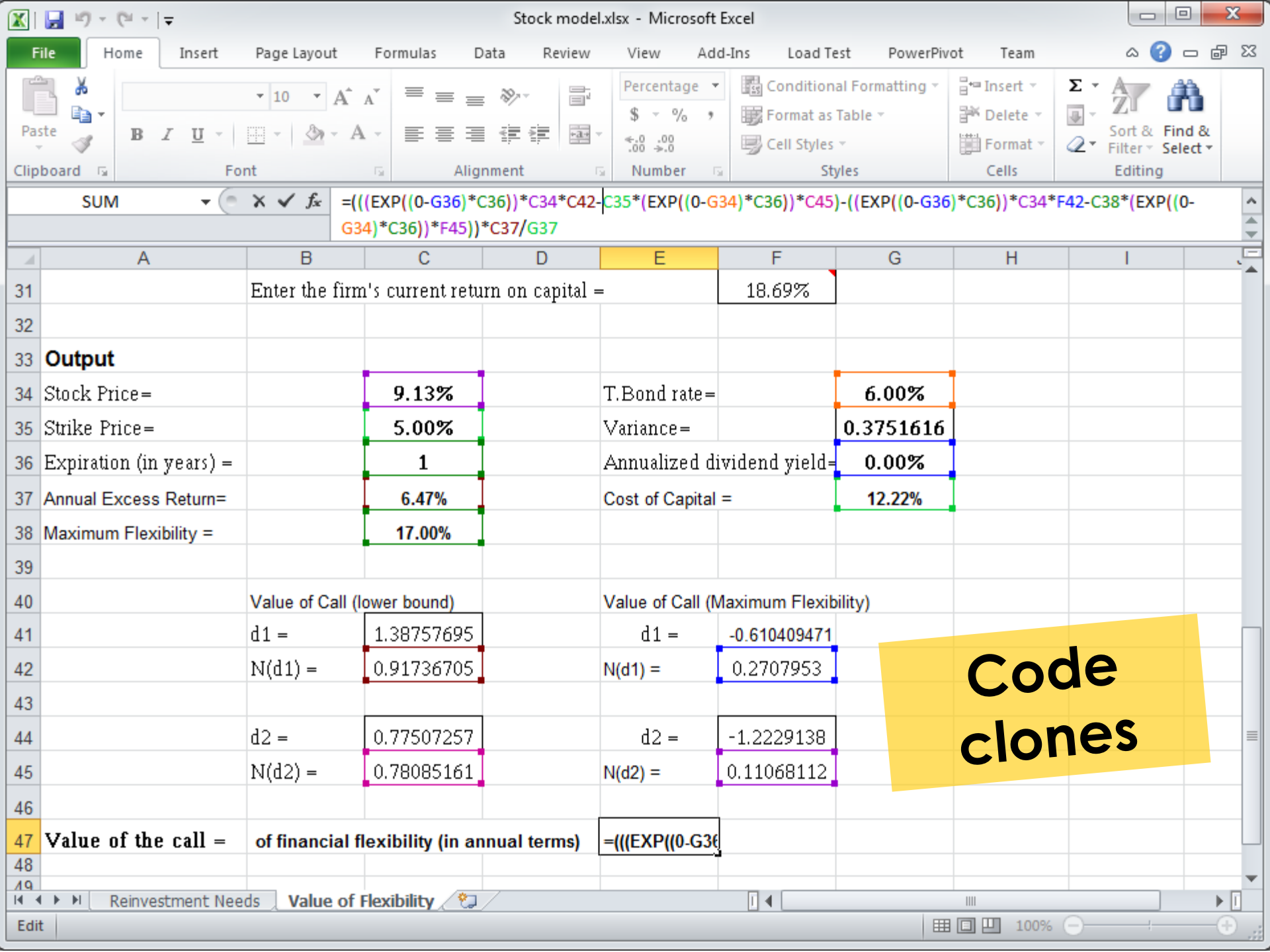
Format
Cells
Sort & Filter
Find & Select
Editing
SUM
=IF(B2>MAX(C2:E2),B2*0.1,IF(B2<=MIN(C2:E2),100,MIN(C2:E2)))
Department
Costs
Costs 2011
Costs 2010
Costs 2009
Pay to headquarters
1 678 699 354 577 =IF(B2>MAX(C2:E2),B
6 302 655 165 157 157
7 780 712 152 926 152
3 252 149 297 336 149
4 668 172 238 916 172
6 147 306 239 280 100
5 455 474 137 238 137
2 726 212 195 207 72.6
8 376 221 307 374 37.6
12 586 377 286 219 58.6
8 720 330 142 793 142
6 982 320 988 726 320
8 259 920 359 792 100
12 825 650 688 957 650
1 658 313 341 168 65.8
12 159 210 116 932 116
7 661 513 476 922 476
2 1000 225 598 222 100
2 732 238 887 931 238
4 250 947 798 123 123
7 328 822 579 906 100
1 770 368 994 902 368
10 671 561 510 799 510
Conditional complexity
Sheet1
Sheet2
Sheet3
Edit
100%


Stock model.xlsx - Microsoft Excel
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Alignment
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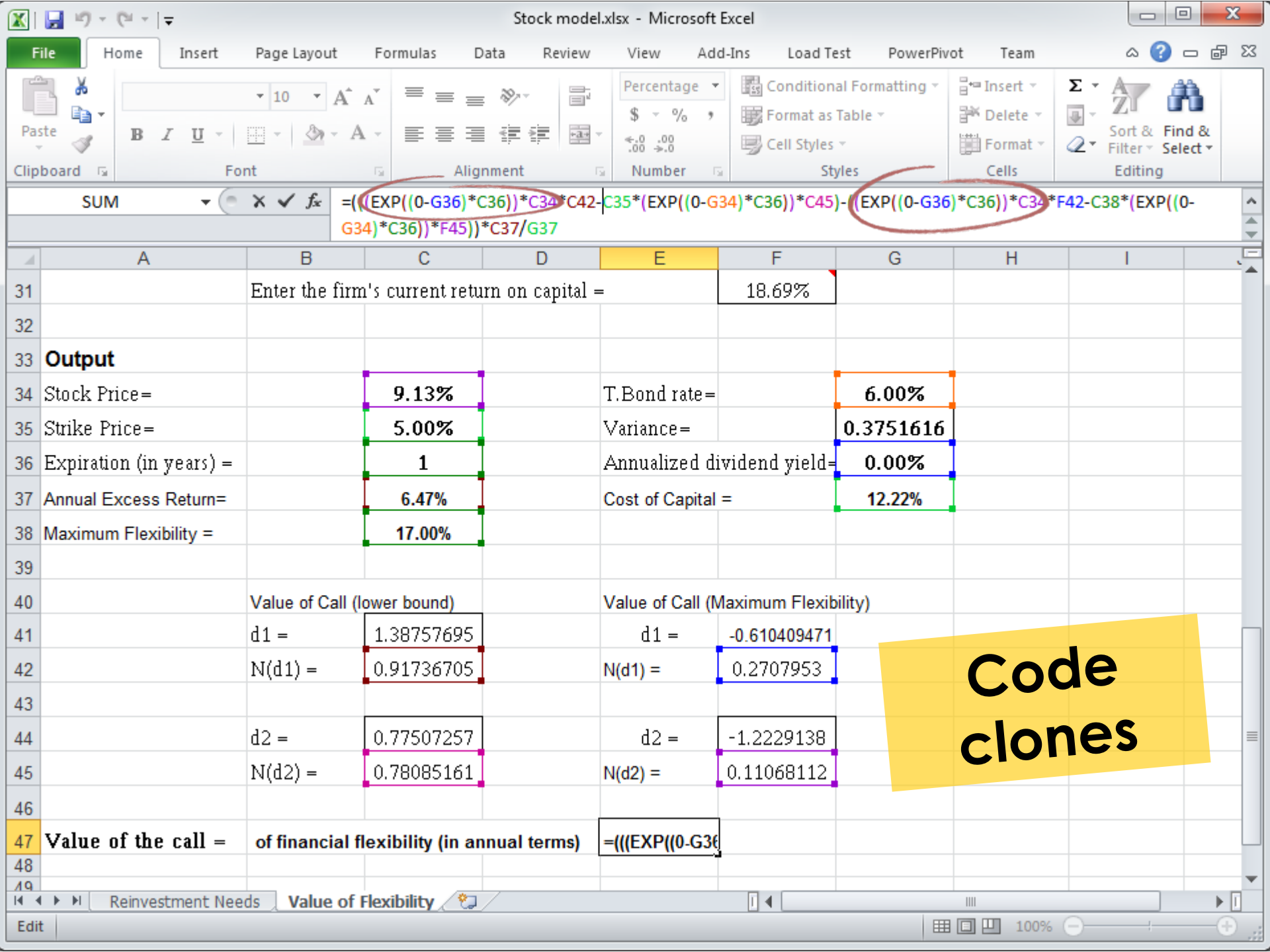
Percentage
Conditional Formatting
Format as Table
Cell Styles
Styles
Insert
Delete
Format
Cells
Sort & Filter
Find & Select
Editing
SUM
=(((EXP((0-G36)*C36))*C34*C42-C35*(EXP((0-G34)*C36))*C45)-((EXP((0-G36)*C36))*C34*F42-C38*(EXP((0-G34)*C36))*F45))*C37/G37
Enter the firm's current return on capital =
18.69%
Output
Stock Price=
9.13%
Strike Price=
5.00%
Expiration (in years) =
1
Annual Excess Return=
6.47%
Maximum Flexibility =
17.00%
T.Bond rate=
6.00%
Variance=
0.3751616
Annualized dividend yield=
0.00%
Cost of Capital =
12.22%
Value of Call (lower bound)
d1 =
1.38757695
N(d1) =
0.91736705
d2 =
0.77507257
N(d2) =
0.78085161
Value of Call (Maximum Flexibility)
d1 =
-0.610409471
N(d1) =
0.2707953
d2 =
-1.2229138
N(d2) =
0.11068112
Value of the call =
of financial flexibility (in annual terms)
=(((EXP((0-G3
Code clones
Reinvestment Needs
Value of Flexibility
Edit
100%


Stock model.xlsx - Microsoft Excel
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Cell Styles
Styles
Insert
Delete
Format
Cells
Sort & Filter
Find & Select
Editing
SUM
=(((EXP((0-G36)*C36))*C34*C42-C35*(EXP((0-G34)*C36))*C45)-(((EXP((0-G36)*C36))*C34*F42-C38*(EXP((0-G34)*C36))*F45))*C37/G37
Enter the firm's current return on capital =
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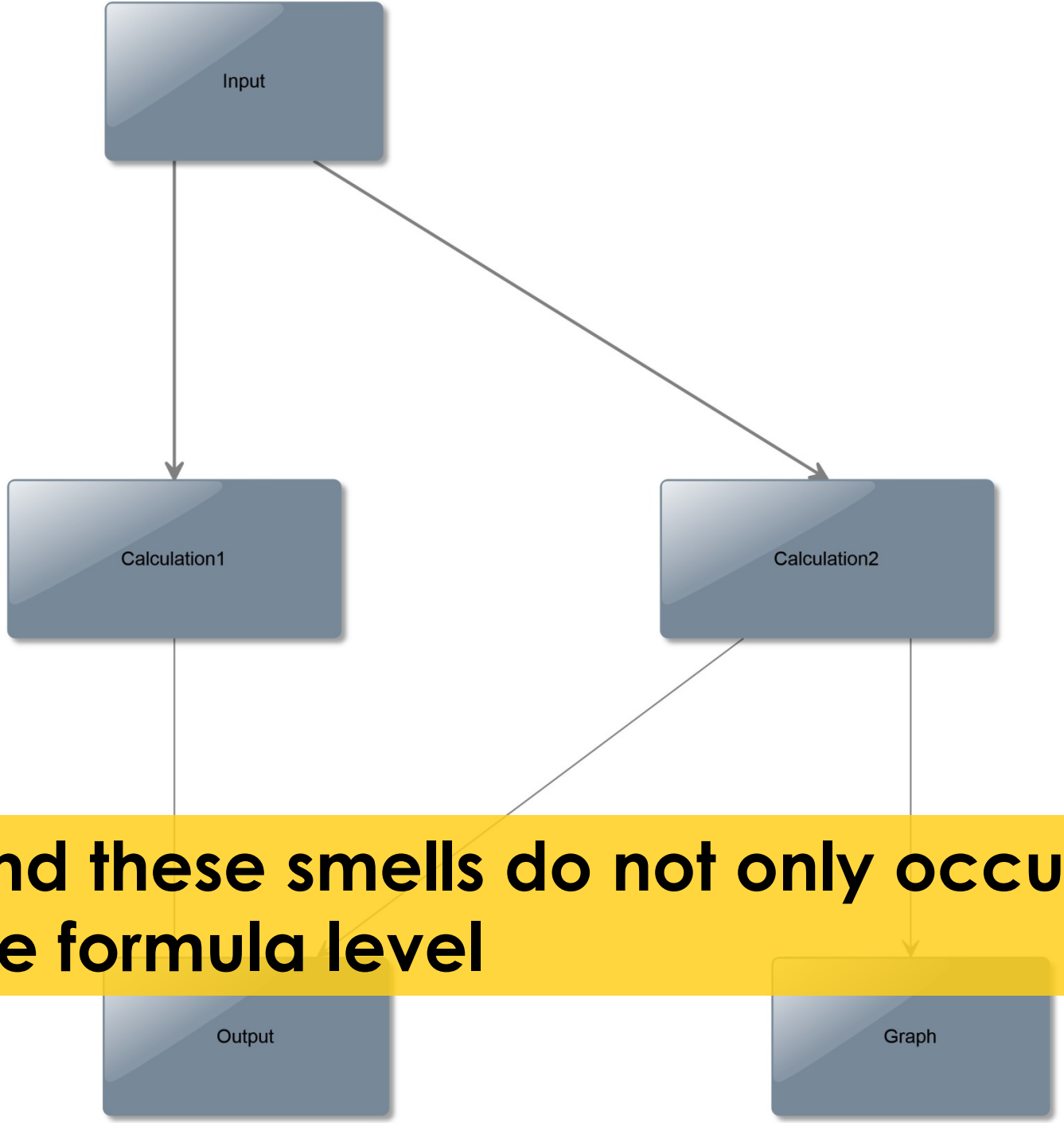
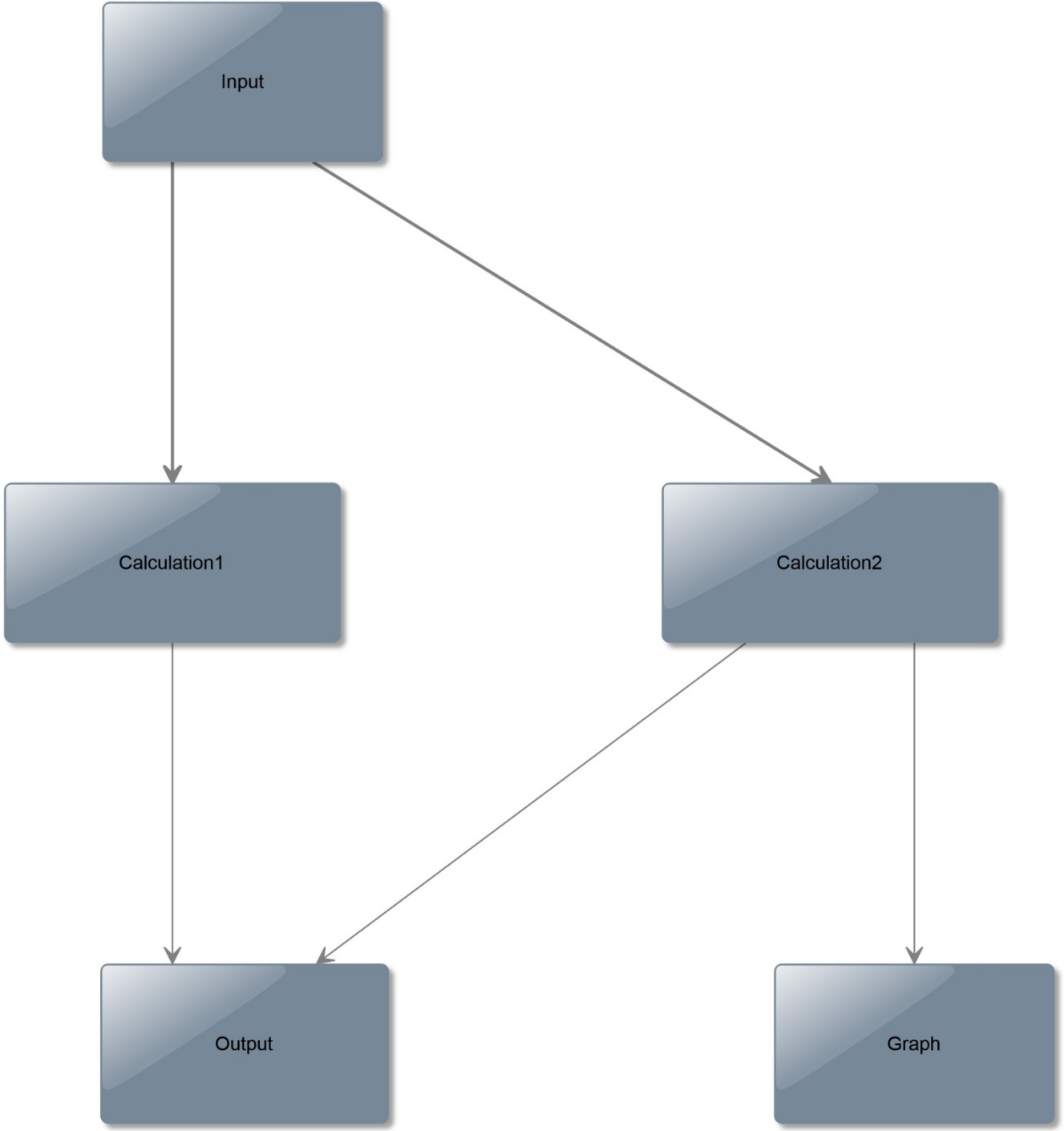
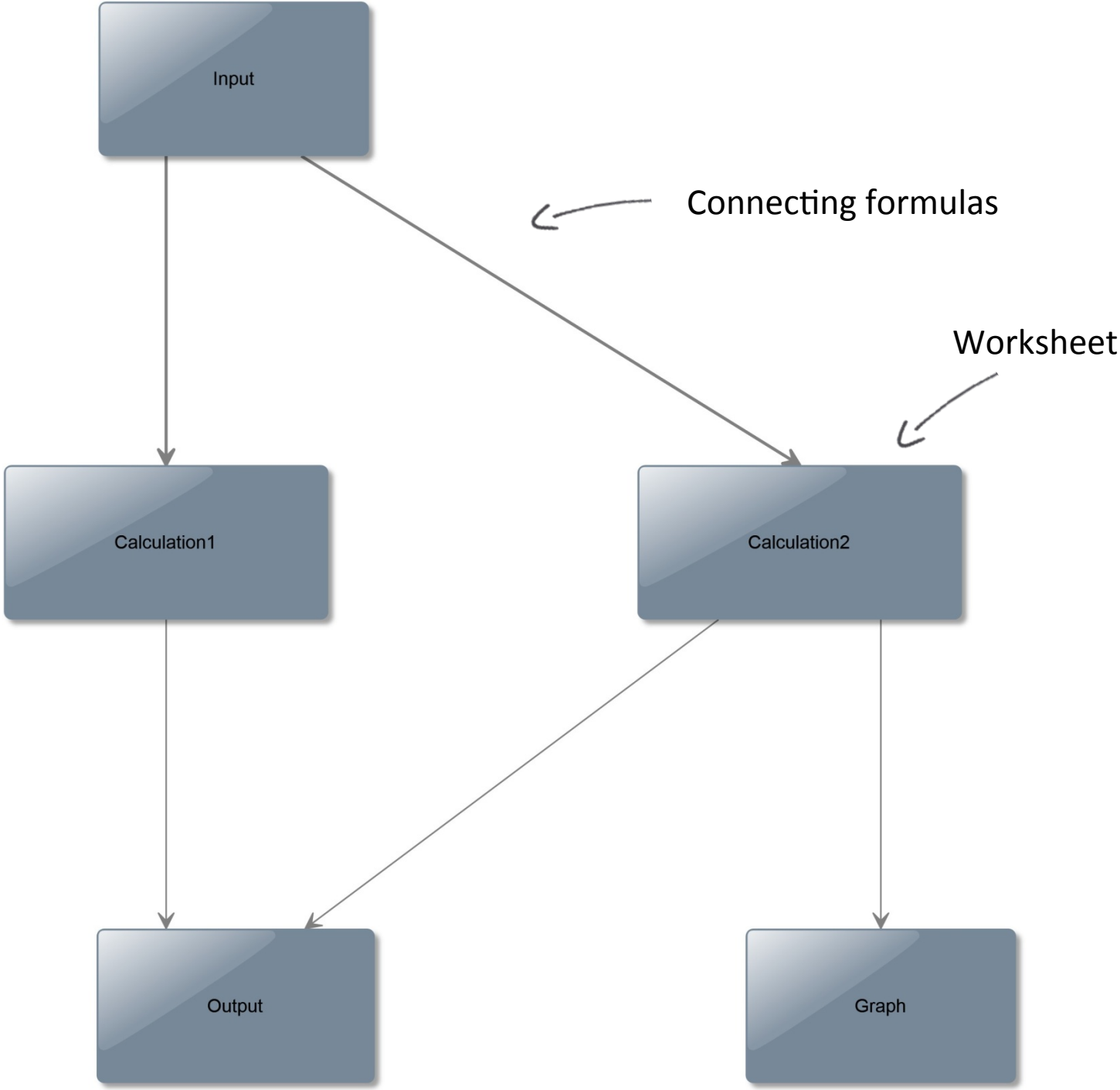
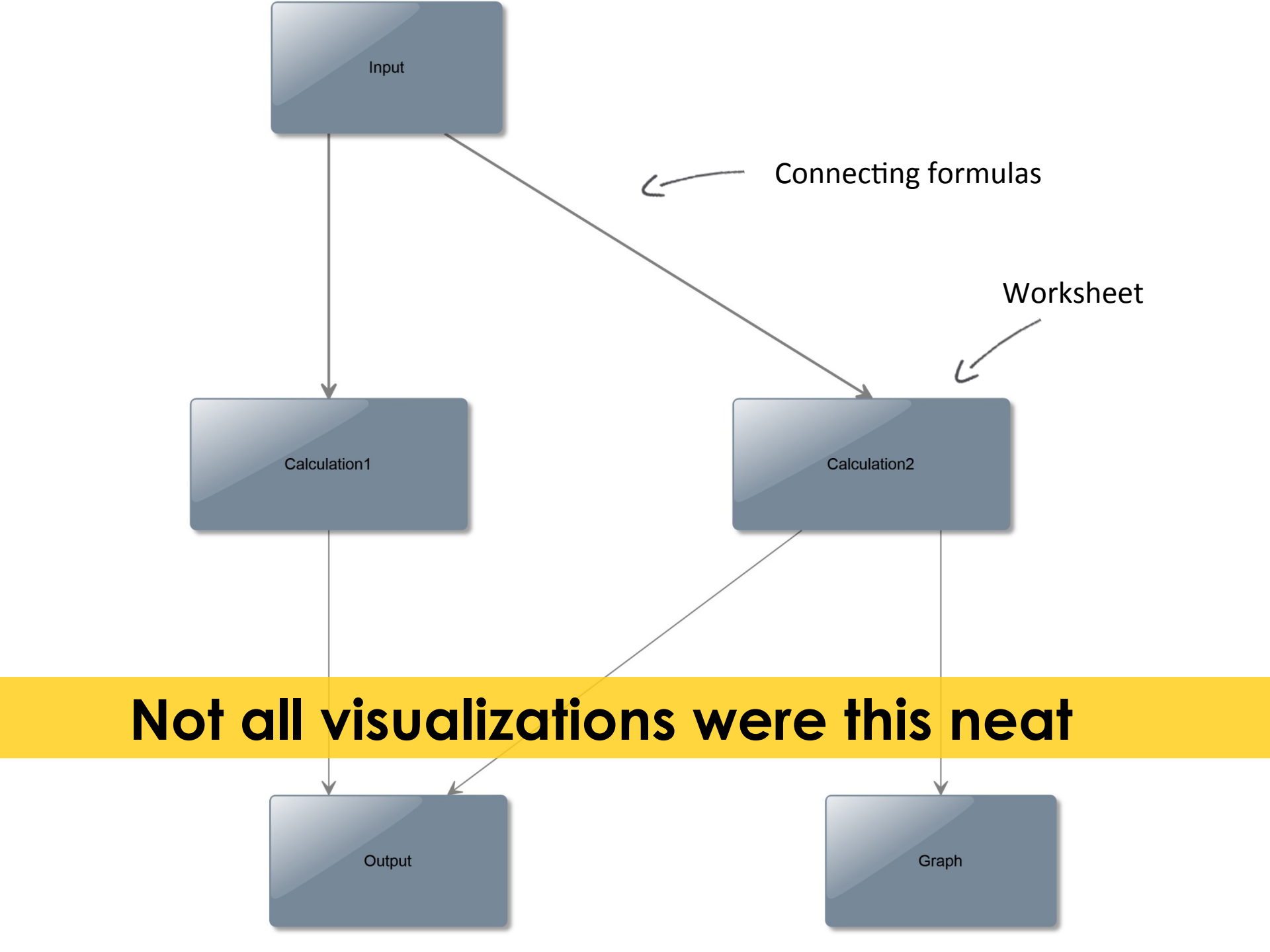
d2 =
-1.2229138
N(d2) =
0.11068112
Value of the call =
of financial flexibility (in annual terms)
=(((EXP((0-G36
Code clones
Reinvestment Needs
Value of Flexibility
Edit
100%



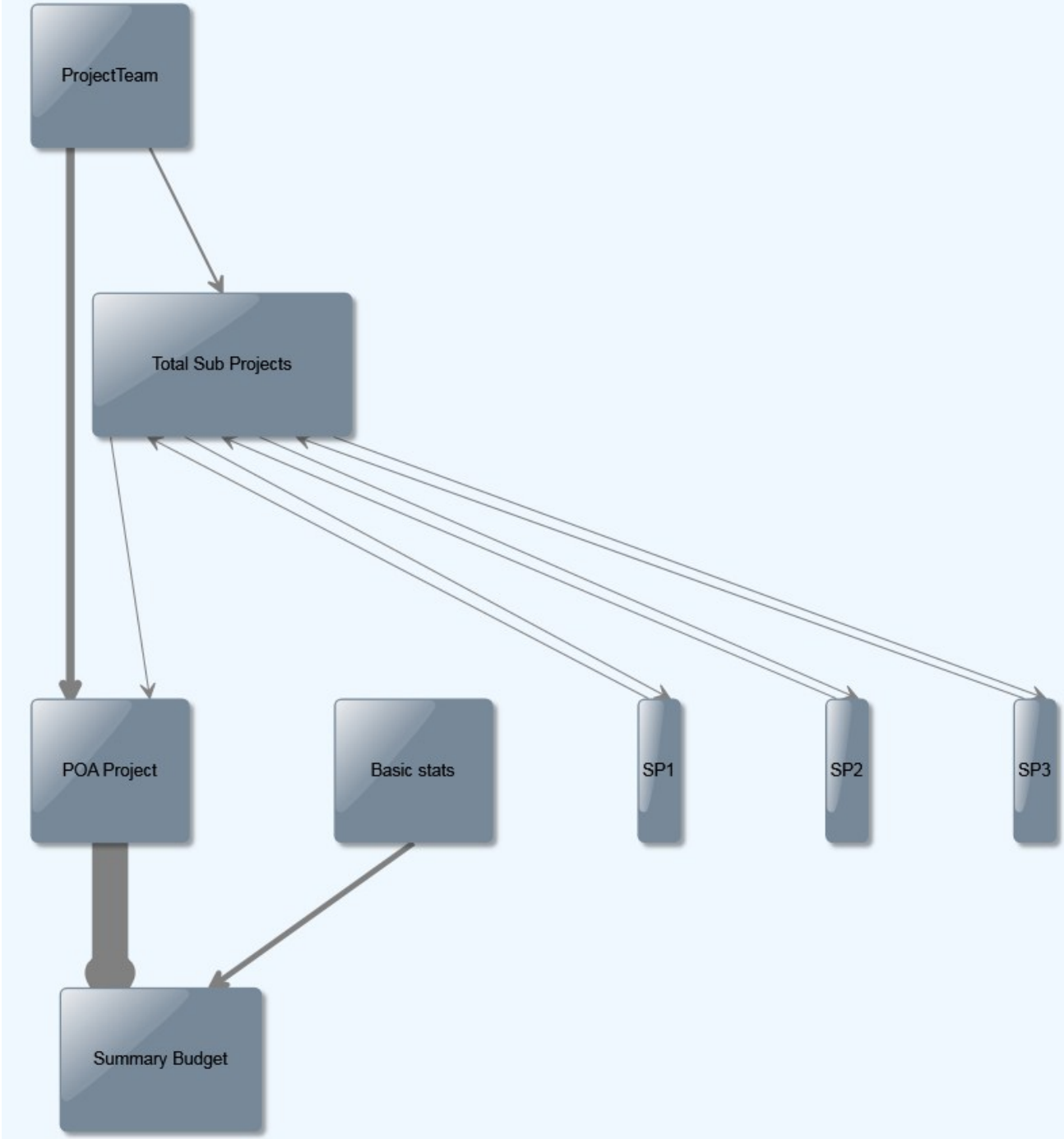
And these smells do not only occur at the formula level


Input
Calculation1
Calculation2
Output
Graph


Input
Connecting formulas
Worksheet
Calculation1
Calculation2
Output
Graph



Not all visualizations were this neat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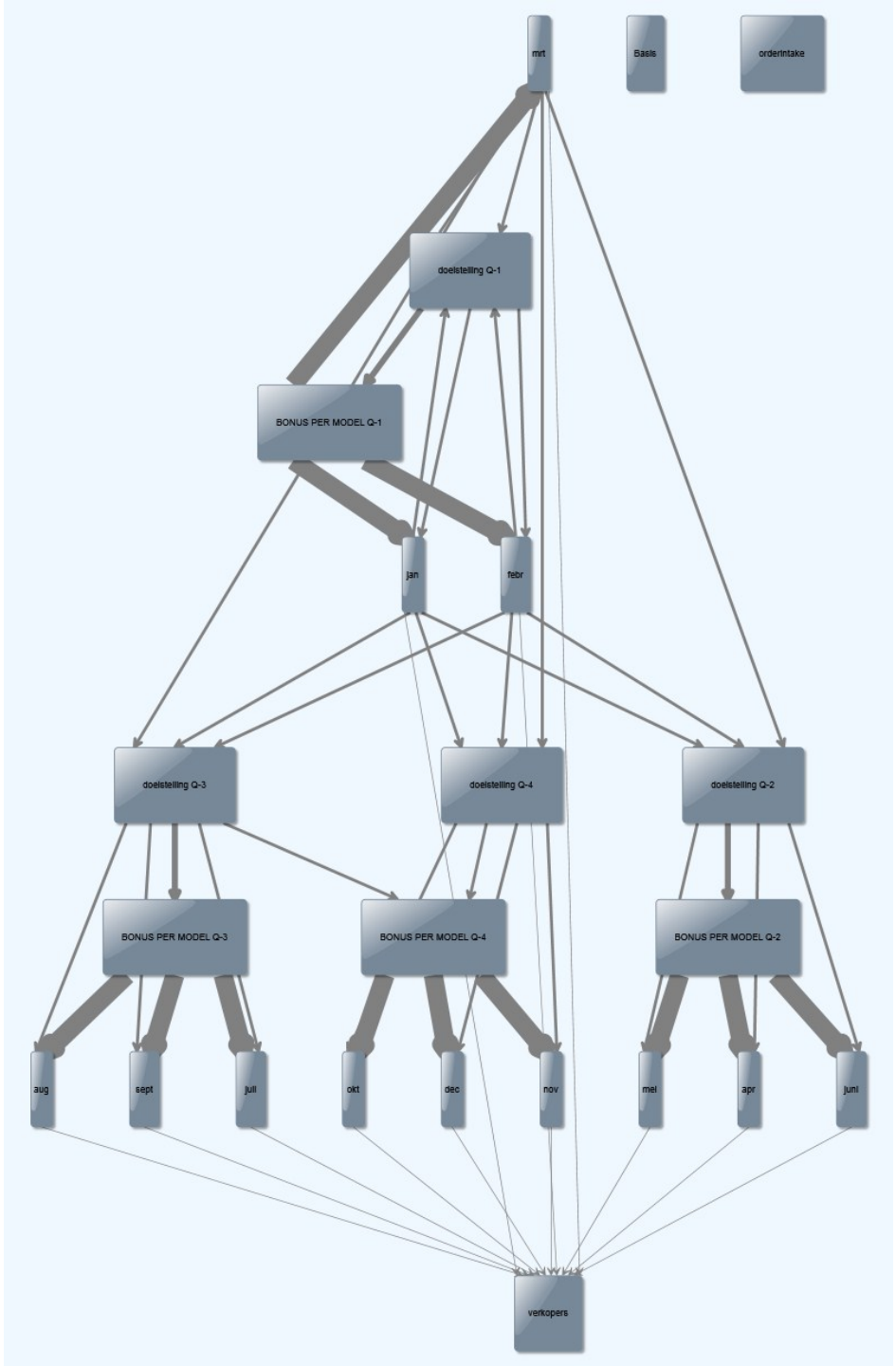
Total Sub Projects
POA Project
Basic stats
SP1
SP2
SP3
Summary Budget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BONUS PER MODEL Q-4
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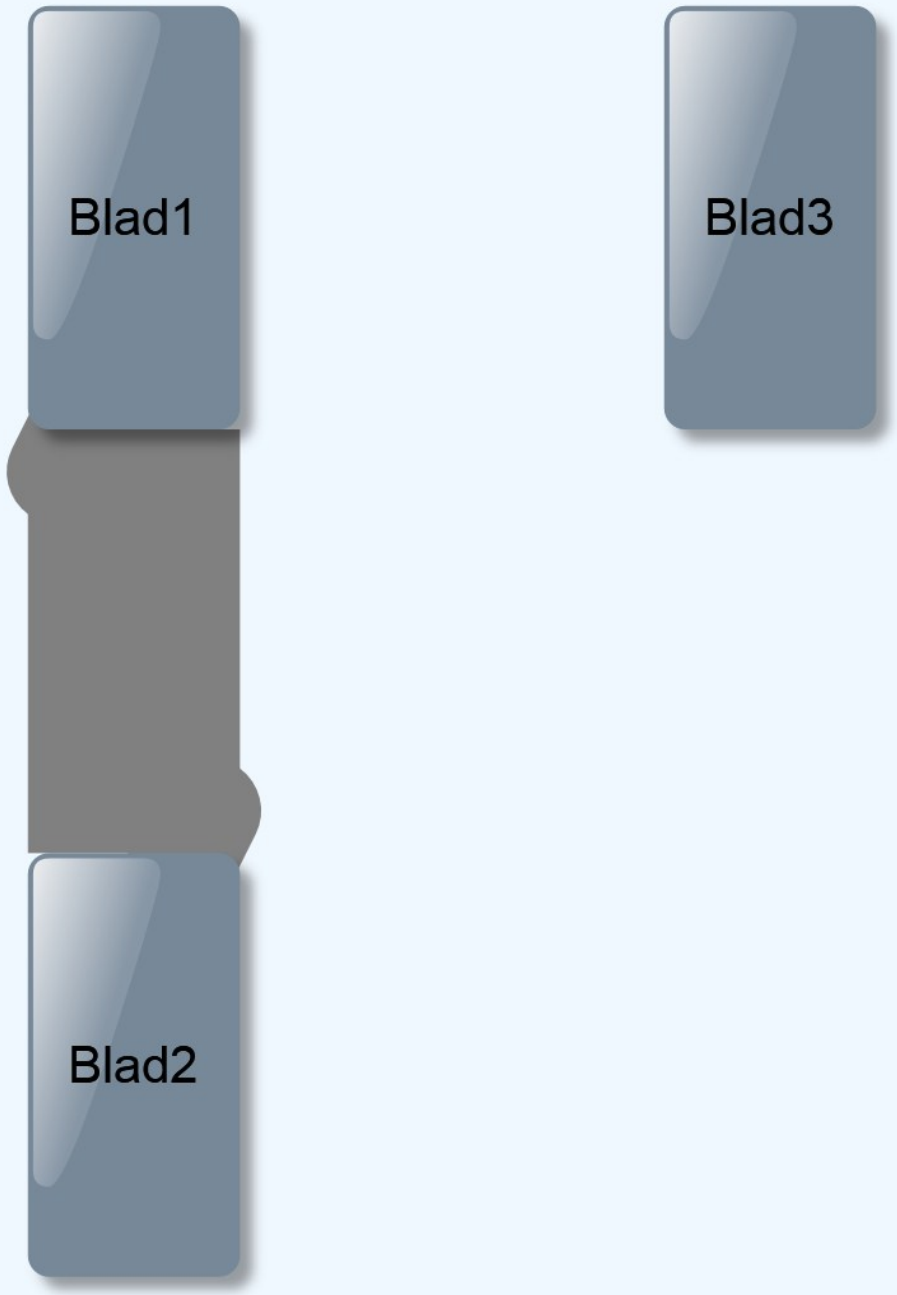
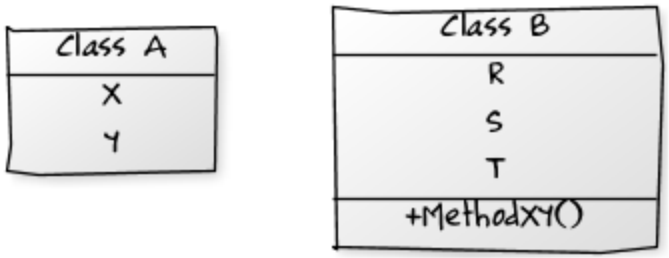

Blad1
Blad3
Blad2

We can conclude:
Smells occur at the structure level too


Class A
X
Y
Class B
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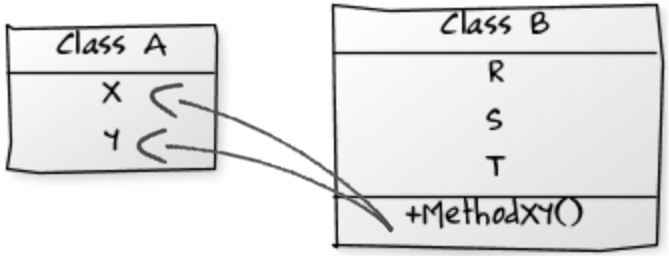
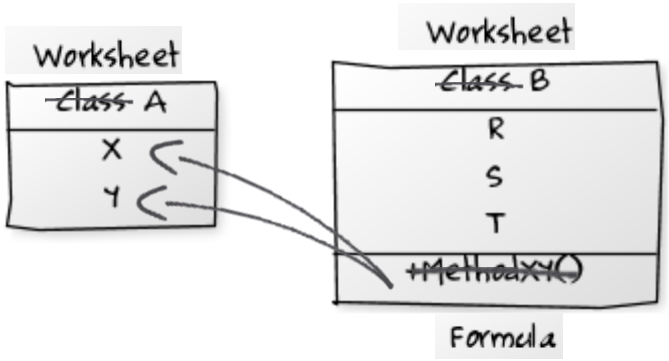
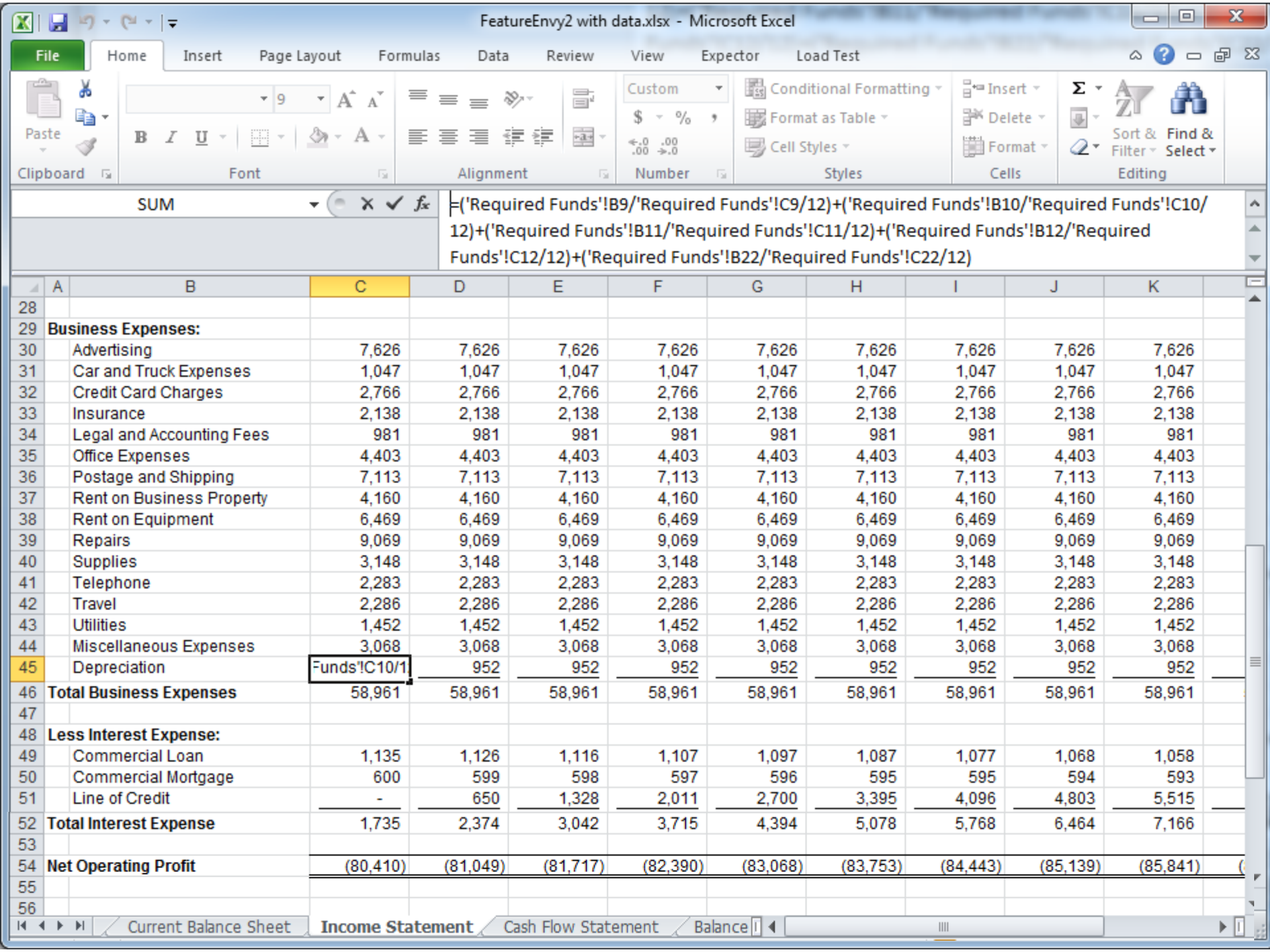
+MethodXY()



This is the ‘feature envy’ smell



This is the ‘feature envy’ smell



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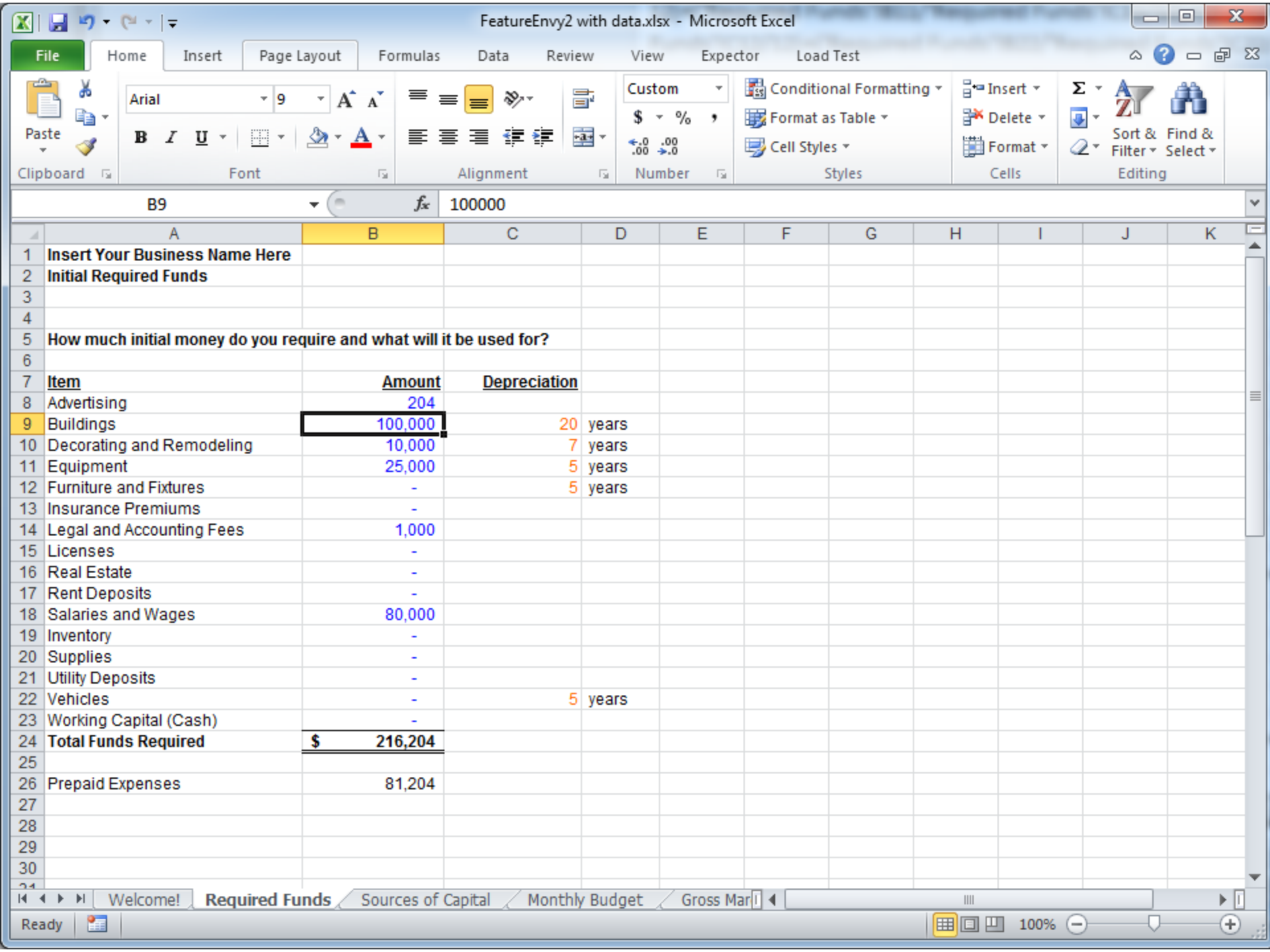
SUM

=('Required Funds'!B9/'Required Funds'!C9/12)+('Required Funds'!B10/'Required Funds'!C10/12)+('Required Funds'!B11/'Required Funds'!C11/12)+('Required Funds'!B12/'Required Funds'!C12/12)+('Required Funds'!B22/'Required Funds'!C22/12)

	A	B	C	D	E	F	G	H	I	J	K
28											
29		**Business Expenses:**									
30		Advertising	7,626	7,626	7,626	7,626	7,626	7,626	7,626	7,626	7,626
31		Car and Truck Expenses	1,047	1,047	1,047	1,047	1,047	1,047	1,047	1,047	1,047
32		Credit Card Charges	2,766	2,766	2,766	2,766	2,766	2,766	2,766	2,766	2,766
33		Insurance	2,138	2,138	2,138	2,138	2,138	2,138	2,138	2,138	2,138
34		Legal and Accounting Fees	981	981	981	981	981	981	981	981	981
35		Office Expenses	4,403	4,403	4,403	4,403	4,403	4,403	4,403	4,403	4,403
36		Postage and Shipping	7,113	7,113	7,113	7,113	7,113	7,113	7,113	7,113	7,113
37		Rent on Business Property	4,160	4,160	4,160	4,160	4,160	4,160	4,160	4,160	4,160
38		Rent on Equipment	6,469	6,469	6,469	6,469	6,469	6,469	6,469	6,469	6,469
39		Repairs	9,069	9,069	9,069	9,069	9,069	9,069	9,069	9,069	9,069
40		Supplies	3,148	3,148	3,148	3,148	3,148	3,148	3,148	3,148	3,148
41		Telephone	2,283	2,283	2,283	2,283	2,283	2,283	2,283	2,283	2,283
42		Travel	2,286	2,286	2,286	2,286	2,286	2,286	2,286	2,286	2,286
43		Utilities	1,452	1,452	1,452	1,452	1,452	1,452	1,452	1,452	1,452
44		Miscellaneous Expenses	3,068	3,068	3,068	3,068	3,068	3,068	3,068	3,068	3,068
45		Depreciation	Funds'!C10/1	952	952	952	952	952	952	952	952
46		**Total Business Expenses**	58,961	58,961	58,961	58,961	58,961	58,961	58,961	58,961	58,961
47											
48		**Less Interest Expense:**									
49		Commercial Loan	1,135	1,126	1,116	1,107	1,097	1,087	1,077	1,068	1,058
50		Commercial Mortgage	600	599	598	597	596	595	595	594	593
51		Line of Credit	-	650	1,328	2,011	2,700	3,395	4,096	4,803	5,515
52		**Total Interest Expense**	1,735	2,374	3,042	3,715	4,394	5,078	5,768	6,464	7,166
53											
54		**Net Operating Profit**	(80,410)	(81,049)	(81,717)	(82,390)	(83,068)	(83,753)	(84,443)	(85,139)	(85,841)
55											
56											

Current Balance Sheet | **Income Statement** | Cash Flow Statement | Balance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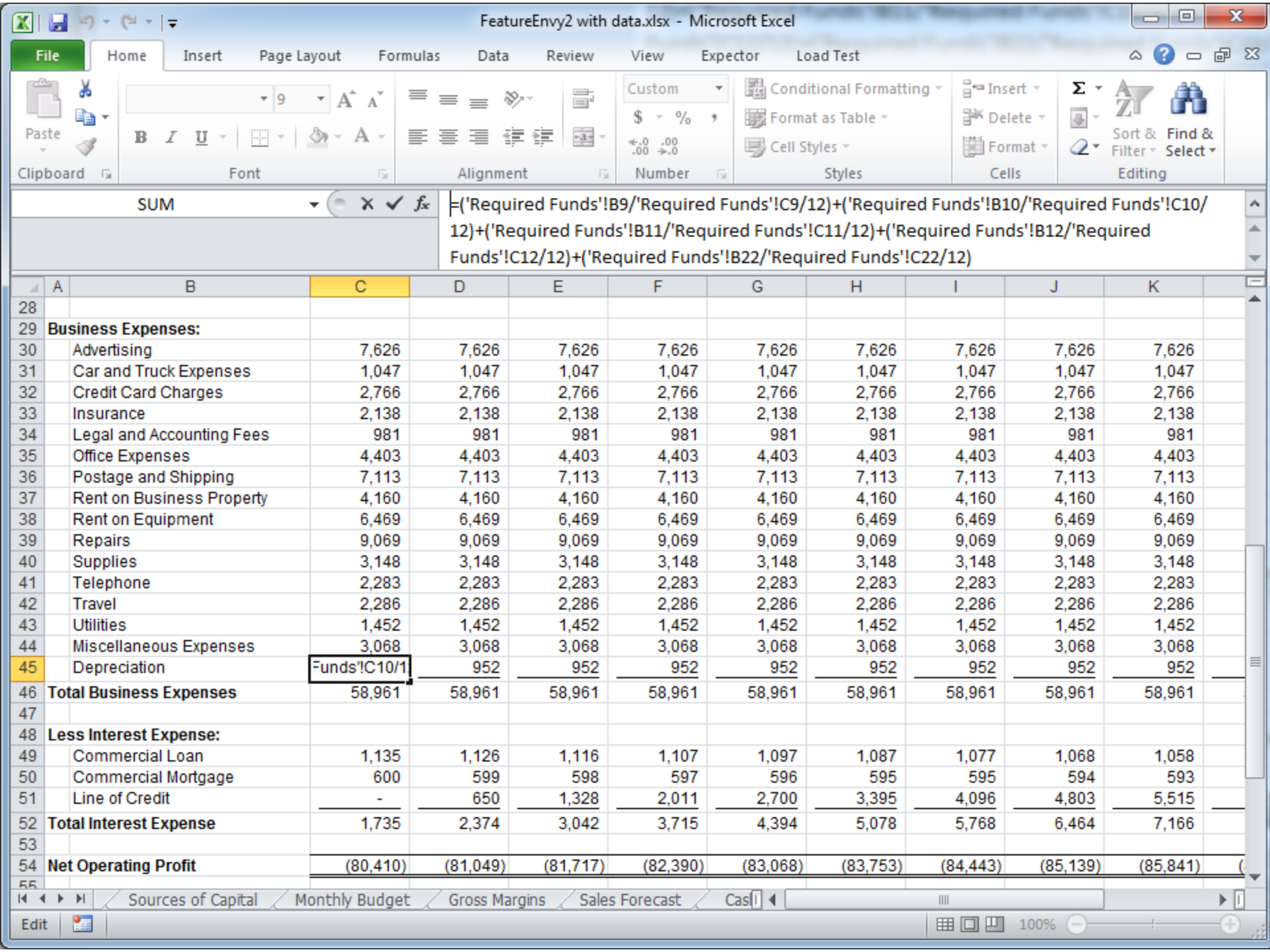
100000
Insert Your Business Name Here
Initial Required Funds
How much initial money do you require and what will it be used for?
Item
Amount
Depreciation
Advertising 204
Buildings 100,000 20 years
Decorating and Remodeling 10,000 7 years
Equipment 25,000 5 years
Furniture and Fixtures - 5 years
Insurance Premiums -
Legal and Accounting Fees 1,000
Licenses -
Real Estate -
Rent Deposits -
Salaries and Wages 80,000
Inventory -
Supplies -
Utility Deposits -
Vehicles - 5 years
Working Capital (Cash) -
Total Funds Required $ 216,204
Prepaid Expenses 81,204
Welcome!
Required Funds
Sources of Capital
Monthly Budget
Gross Mar
Ready
100%



	A	B	C	D	E	F	G	H	I	J	K
28											
29		**Business Expenses:**									
30		Advertising	7,626	7,626	7,626	7,626	7,626	7,626	7,626	7,626	7,626
31		Car and Truck Expenses	1,047	1,047	1,047	1,047	1,047	1,047	1,047	1,047	1,047
32		Credit Card Charges	2,766	2,766	2,766	2,766	2,766	2,766	2,766	2,766	2,766
33		Insurance	2,138	2,138	2,138	2,138	2,138	2,138	2,138	2,138	2,138
34		Legal and Accounting Fees	981	981	981	981	981	981	981	981	981
35		Office Expenses	4,403	4,403	4,403	4,403	4,403	4,403	4,403	4,403	4,403
36		Postage and Shipping	7,113	7,113	7,113	7,113	7,113	7,113	7,113	7,113	7,113
37		Rent on Business Property	4,160	4,160	4,160	4,160	4,160	4,160	4,160	4,160	4,160
38		Rent on Equipment	6,469	6,469	6,469	6,469	6,469	6,469	6,469	6,469	6,469
39		Repairs	9,069	9,069	9,069	9,069	9,069	9,069	9,069	9,069	9,069
40		Supplies	3,148	3,148	3,148	3,148	3,148	3,148	3,148	3,148	3,148
41		Telephone	2,283	2,283	2,283	2,283	2,283	2,283	2,283	2,283	2,283
42		Travel	2,286	2,286	2,286	2,286	2,286	2,286	2,286	2,286	2,286
43		Utilities	1,452	1,452	1,452	1,452	1,452	1,452	1,452	1,452	1,452
44		Miscellaneous Expenses	3,068	3,068	3,068	3,068	3,068	3,068	3,068	3,068	3,068
45		Depreciation	Funds'!C10/1	952	952	952	952	952	952	952	952
46		**Total Business Expenses**	58,961	58,961	58,961	58,961	58,961	58,961	58,961	58,961	58,961
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48		**Less Interest Expense:**									
49		Commercial Loan	1,135	1,126	1,116	1,107	1,097	1,087	1,077	1,068	1,058
50		Commercial Mortgage	600	599	598	597	596	595	595	594	593
51		Line of Credit	-	650	1,328	2,011	2,700	3,395	4,096	4,803	5,515
52		**Total Interest Expense**	1,735	2,374	3,042	3,715	4,394	5,078	5,768	6,464	7,166
53											
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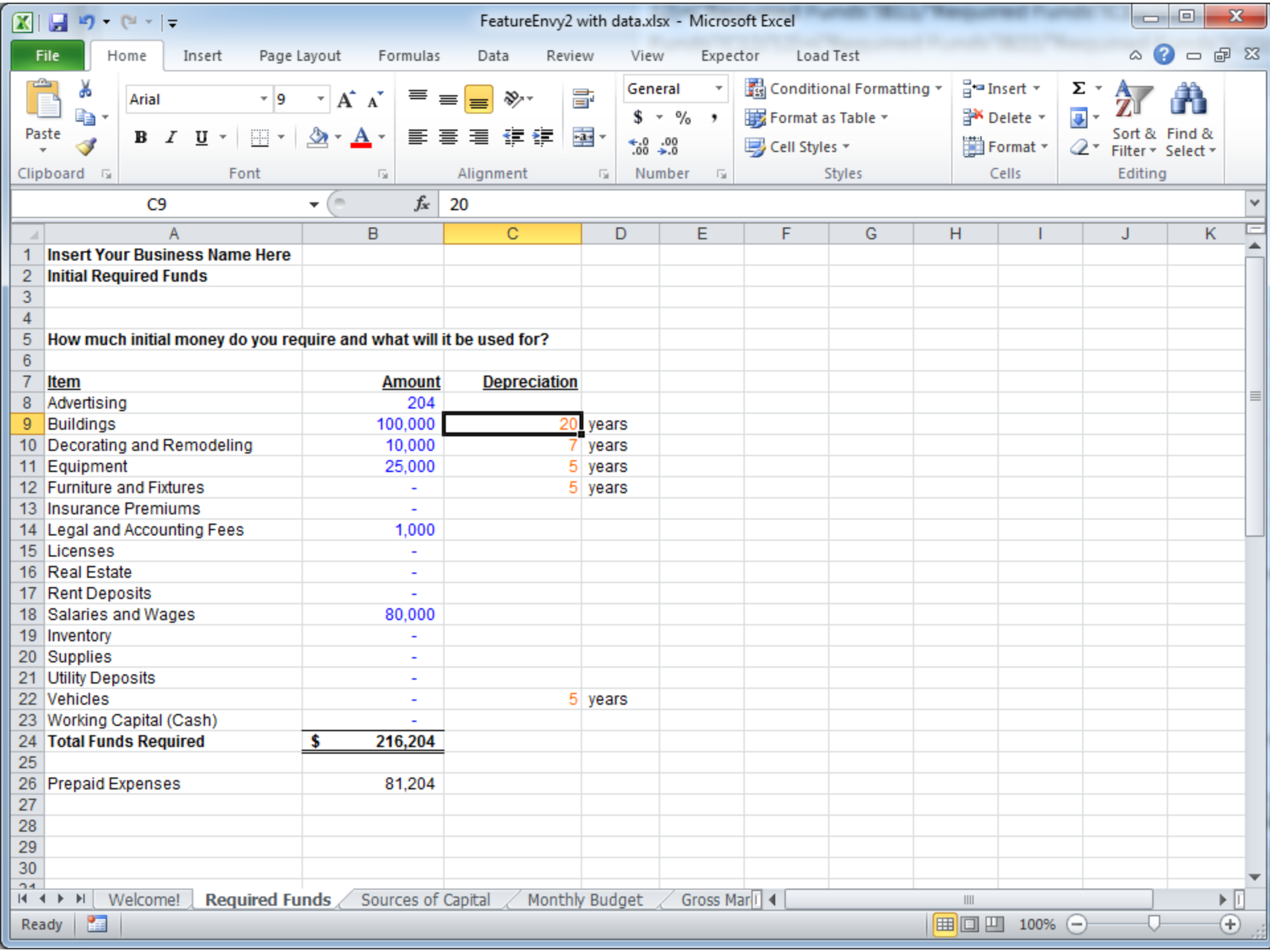
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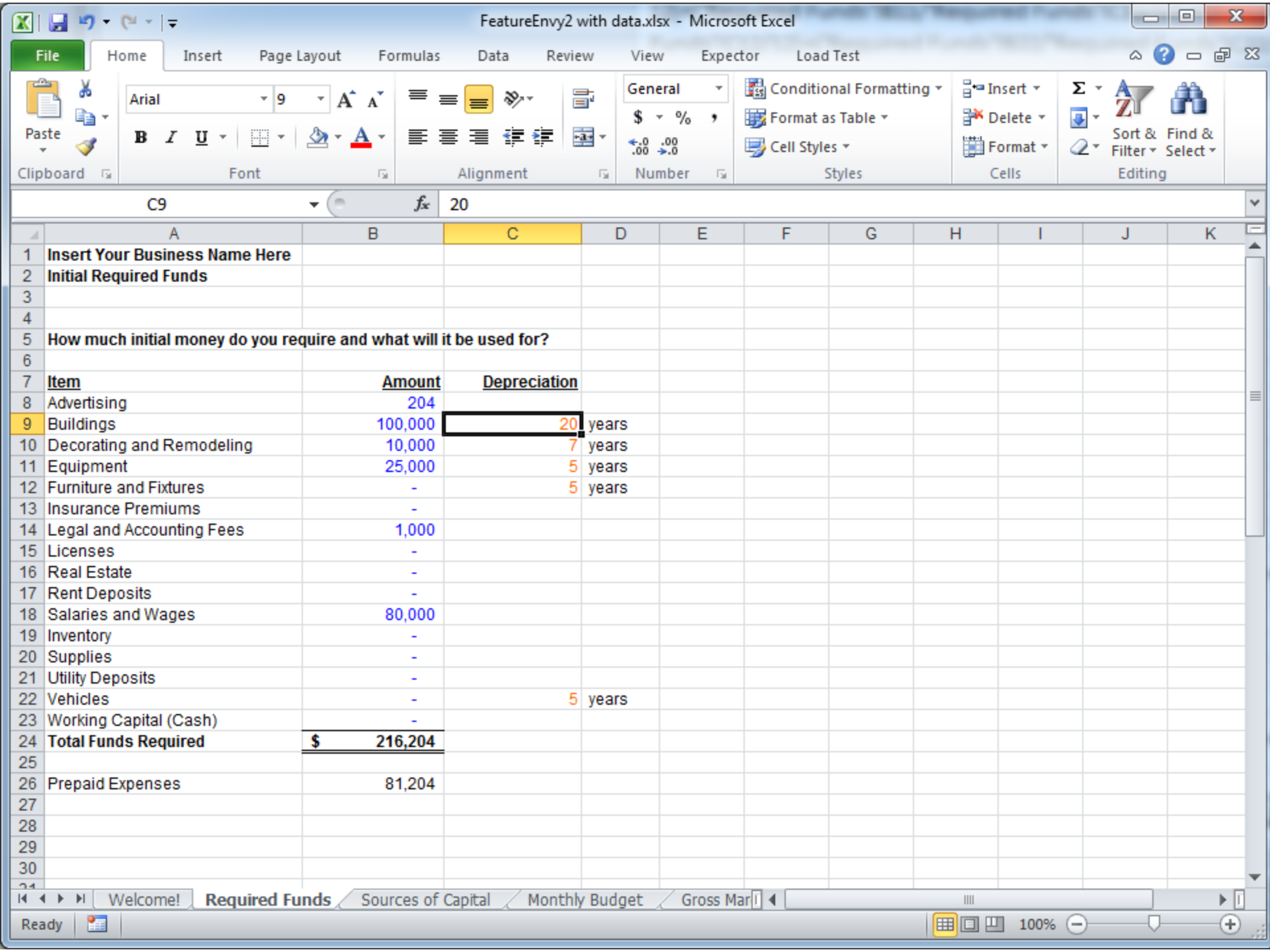
20
Insert Your Business Name Here
Initial Required Funds
How much initial money do you require and what will it be used for?
Item
Amount
Depreciation
Advertising 204
Buildings 100,000 20 years
Decorating and Remodeling 10,000 7 years
Equipment 25,000 5 years
Furniture and Fixtures - 5 years
Insurance Premiums -
Legal and Accounting Fees 1,000
Licenses -
Real Estate -
Rent Deposits -
Salaries and Wages 80,000
Inventory -
Supplies -
Utility Deposits -
Vehicles - 5 years
Working Capital (Cash) -
Total Funds Required $ 216,204
Prepaid Expenses 81,204
Welcome!
Required Funds
Sources of Capital
Monthly Budget
Gross Mar
Ready
100%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20
Insert Your Business Name Here
Initial Required Funds
How much initial money do you require and what will it be used for?
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Depreciation
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Buildings 100,000 20 years
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Furniture and Fixtures - 5 years
Insurance Premiums -
Legal and Accounting Fees 1,000
Licenses -
Real Estate -
Rent Deposits -
Salaries and Wages 80,000
Inventory -
Supplies -
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Working Capital (Cash) -
Total Funds Required $ 216,204
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Welcome!
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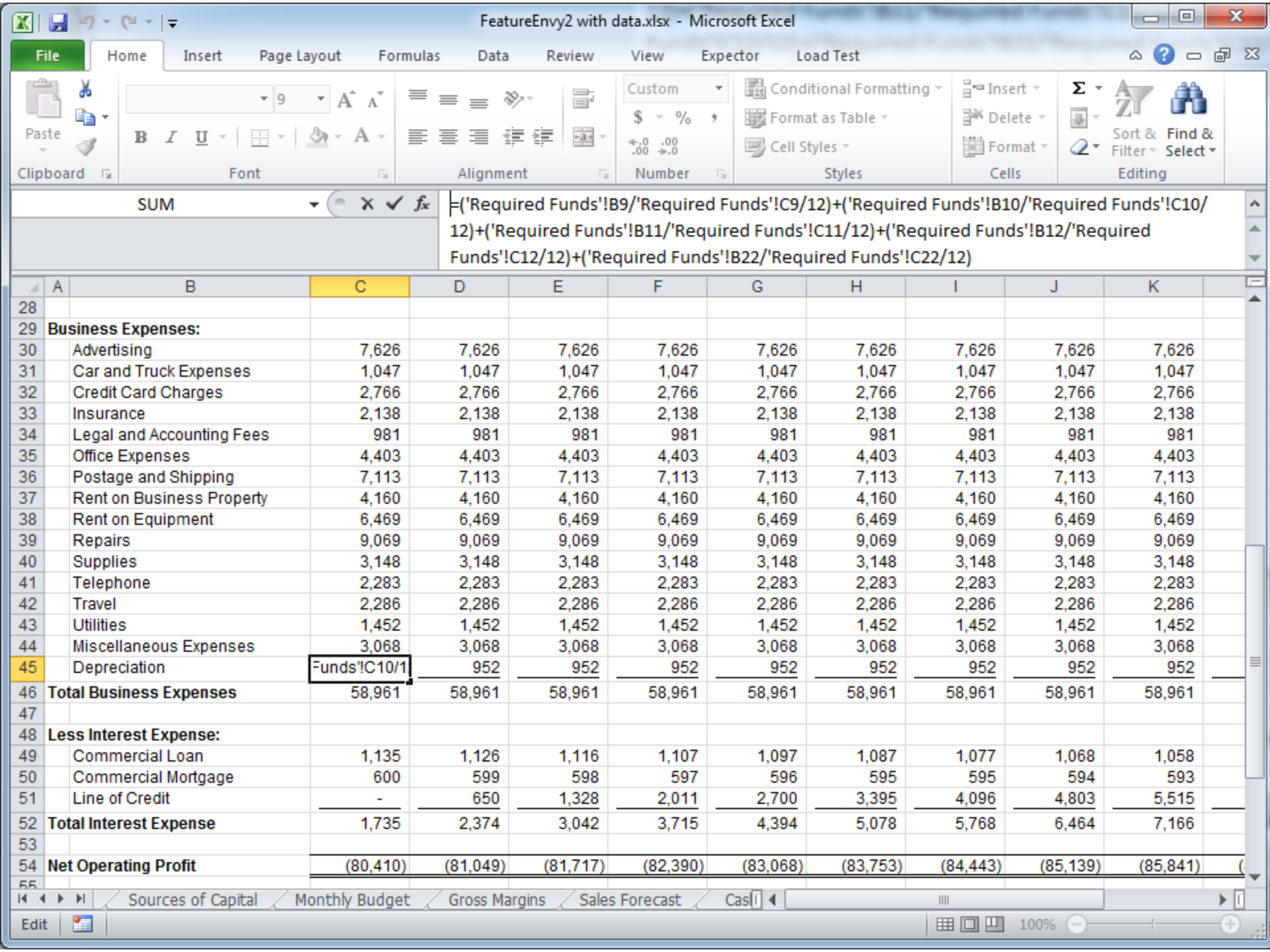
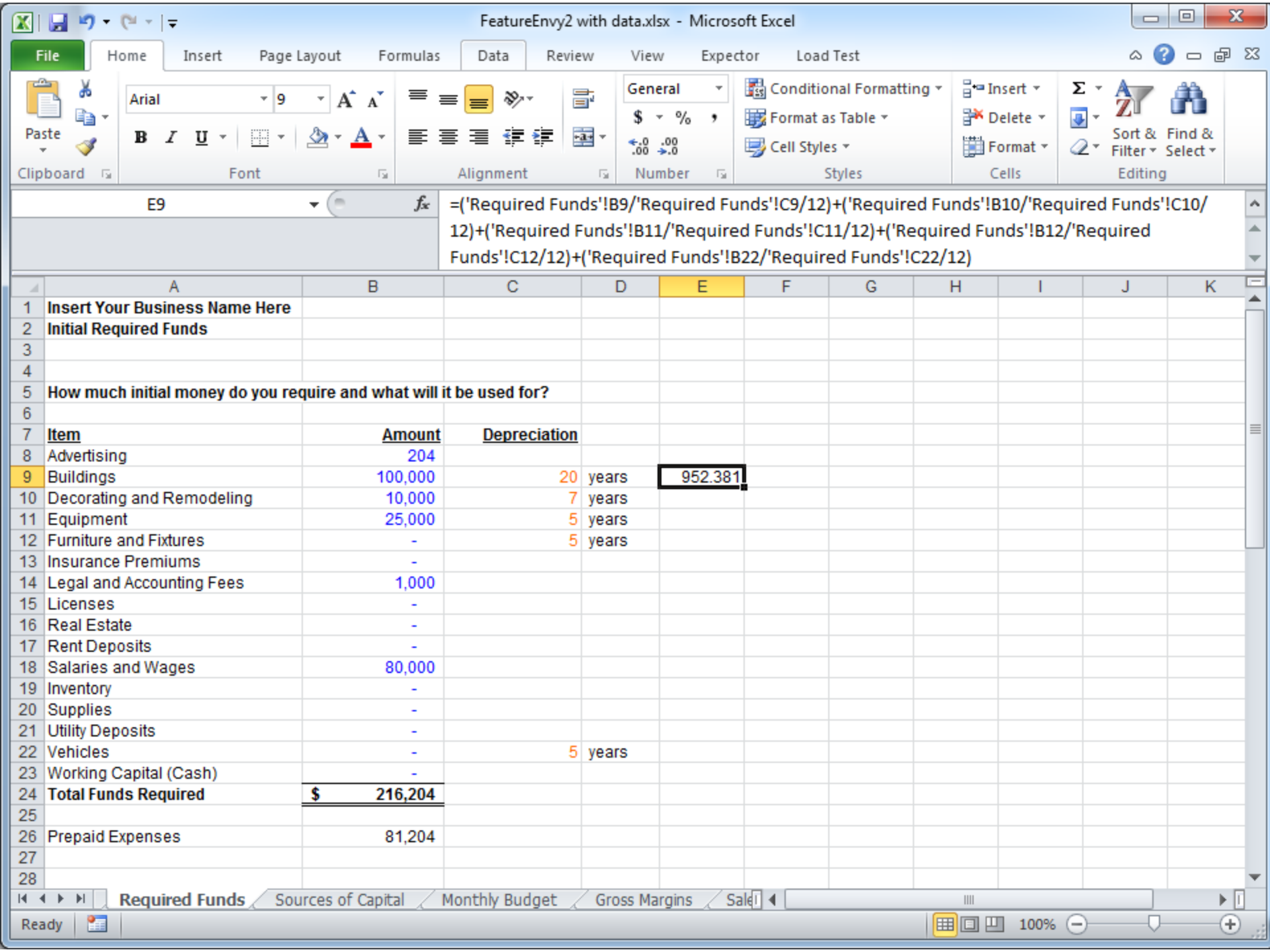
Gross Mar
Ready
100%



	A	B	C	D	E	F	G	H	I	J	K
28											
29		**Business Expenses:**									
30		Advertising	7,626	7,626	7,626	7,626	7,626	7,626	7,626	7,626	7,626
31		Car and Truck Expenses	1,047	1,047	1,047	1,047	1,047	1,047	1,047	1,047	1,047
32		Credit Card Charges	2,766	2,766	2,766	2,766	2,766	2,766	2,766	2,766	2,766
33		Insurance	2,138	2,138	2,138	2,138	2,138	2,138	2,138	2,138	2,138
34		Legal and Accounting Fees	981	981	981	981	981	981	981	981	981
35		Office Expenses	4,403	4,403	4,403	4,403	4,403	4,403	4,403	4,403	4,403
36		Postage and Shipping	7,113	7,113	7,113	7,113	7,113	7,113	7,113	7,113	7,113
37		Rent on Business Property	4,160	4,160	4,160	4,160	4,160	4,160	4,160	4,160	4,160
38		Rent on Equipment	6,469	6,469	6,469	6,469	6,469	6,469	6,469	6,469	6,469
39		Repairs	9,069	9,069	9,069	9,069	9,069	9,069	9,069	9,069	9,069
40		Supplies	3,148	3,148	3,148	3,148	3,148	3,148	3,148	3,148	3,148
41		Telephone	2,283	2,283	2,283	2,283	2,283	2,283	2,283	2,283	2,283
42		Travel	2,286	2,286	2,286	2,286	2,286	2,286	2,286	2,286	2,286
43		Utilities	1,452	1,452	1,452	1,452	1,452	1,452	1,452	1,452	1,452
44		Miscellaneous Expenses	3,068	3,068	3,068	3,068	3,068	3,068	3,068	3,068	3,068
45		Depreciation	Funds'!C10/1	952	952	952	952	952	952	952	952
46		**Total Business Expenses**	58,961	58,961	58,961	58,961	58,961	58,961	58,961	58,961	58,961
47											
48		**Less Interest Expense:**									
49		Commercial Loan	1,135	1,126	1,116	1,107	1,097	1,087	1,077	1,068	1,058
50		Commercial Mortgage	600	599	598	597	596	595	595	594	593
51		Line of Credit	-	650	1,328	2,011	2,700	3,395	4,096	4,803	5,515
52		**Total Interest Expense**	1,735	2,374	3,042	3,715	4,394	5,078	5,768	6,464	7,166
53											
54		**Net Operating Profit**	(80,410)	(81,049)	(81,717)	(82,390)	(83,068)	(83,753)	(84,443)	(85,139)	(85,841)


FeatureEnvy2 with data.xlsx - Microsoft Excel
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General
Conditional Formatting
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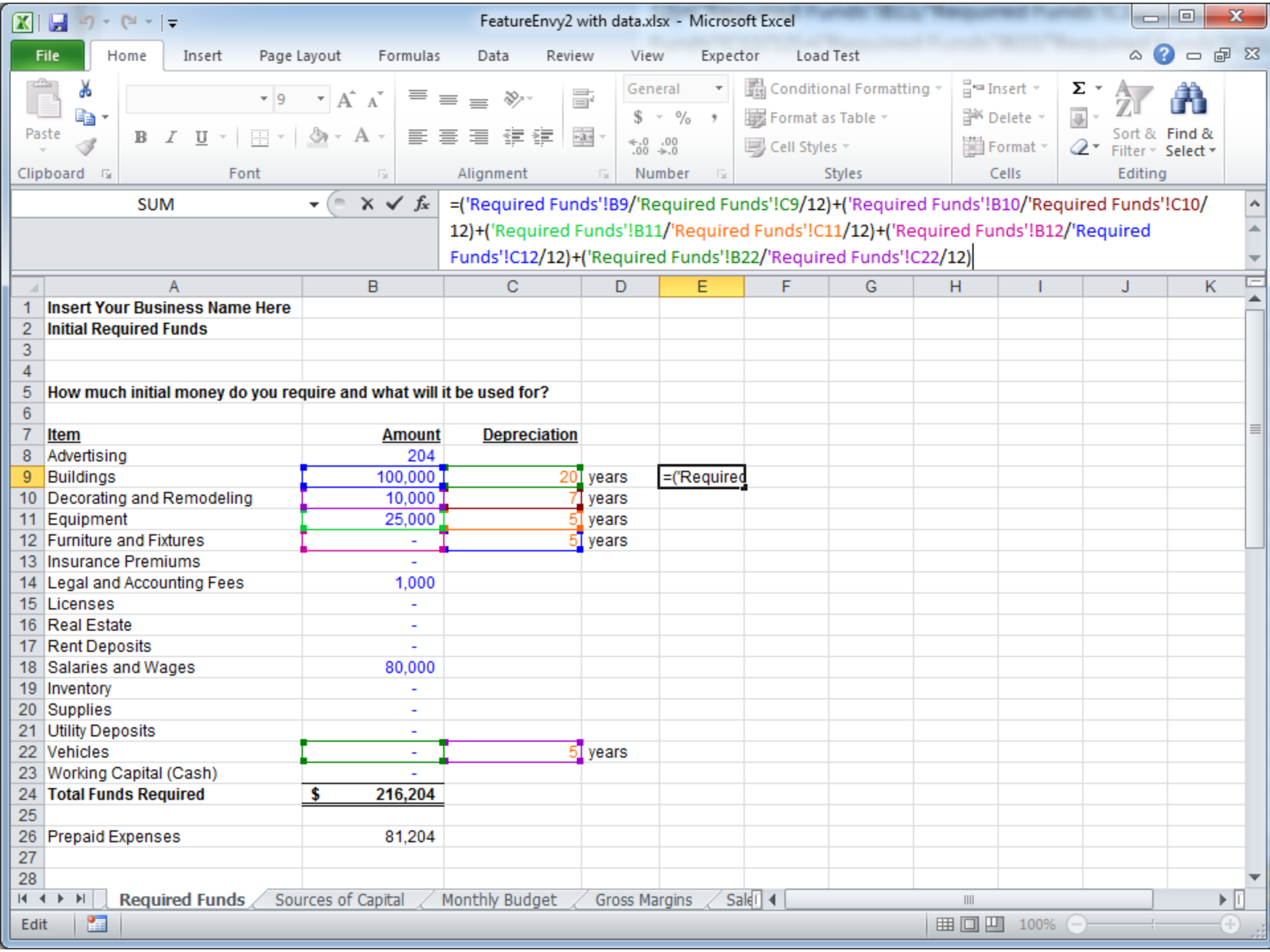
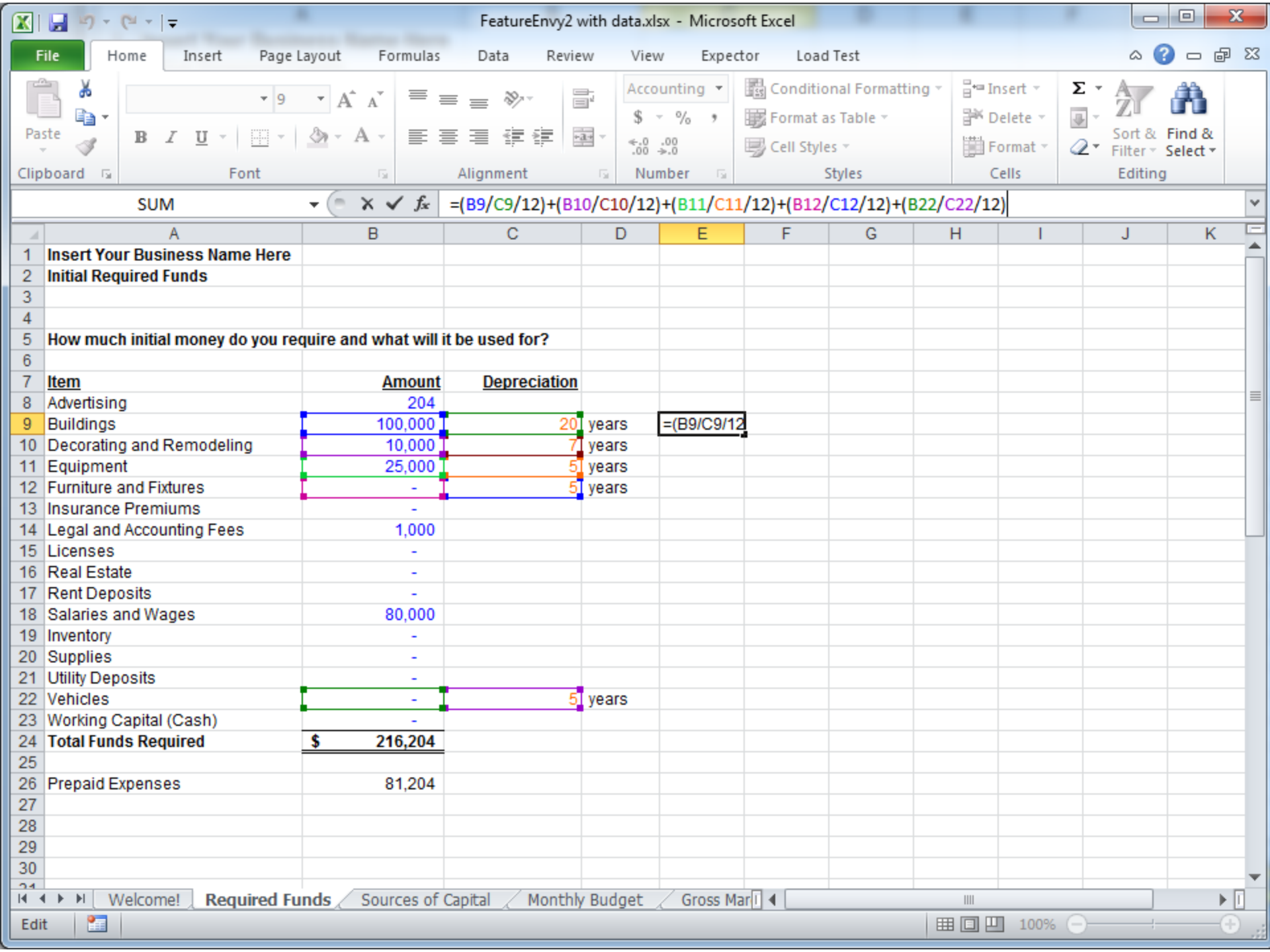
Editing
E9
=('Required Funds'!B9/'Required Funds'!C9/12)+('Required Funds'!B10/'Required Funds'!C10/12)+('Required Funds'!B11/'Required Funds'!C11/12)+('Required Funds'!B12/'Required Funds'!C12/12)+('Required Funds'!B22/'Required Funds'!C22/12)
Insert Your Business Name Here
Initial Required Funds
How much initial money do you require and what will it be used for?
Item
Amount
Depreciation
Advertising 204
Buildings 100,000 20 years 952.381
Decorating and Remodeling 10,000 7 years
Equipment 25,000 5 years
Furniture and Fixtures - 5 years
Insurance Premiums -
Legal and Accounting Fees 1,000
Licenses -
Real Estate -
Rent Deposits -
Salaries and Wages 80,000
Inventory -
Supplies -
Utility Deposits -
Vehicles - 5 years
Working Capital (Cash) -
Total Funds Required $ 216,204
Prepaid Expenses 81,204
Required Funds
Sources of Capital
Monthly Budget
Gross Margins
Ready
100%



	A	B	C	D	E
1	**Insert Your Business Name Here**				
2	**Initial Required Funds**				
3					
4					
5	**How much initial money do you require and what will it be used for?**				
6					
7	**Item**	**Amount**	**Depreciation**		
8	Advertising	204			
9	Buildings	100,000	20	years	=('Required
10	Decorating and Remodeling	10,000	7	years	
11	Equipment	25,000	5	years	
12	Furniture and Fixtures	-	5	years	
13	Insurance Premiums	-			
14	Legal and Accounting Fees	1,000			
15	Licenses	-			
16	Real Estate	-			
17	Rent Deposits	-			
18	Salaries and Wages	80,000			
19	Inventory	-			
20	Supplies	-			
21	Utility Deposits	-			
22	Vehicles	-	5	years	
23	Working Capital (Cash)	-			
24	**Total Funds Required**	**$ 216,204**			
25					
26	Prepaid Expenses	81,204			
27					
28					


FeatureEnvy2 with data.xlsx - Microsoft Excel
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Number
Accounting
Conditional Formatting
Format as Table
Cell Styles
Styles
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Sort & Filter
Find & Select
Editing
SUM
=(B9/C9/12)+(B10/C10/12)+(B11/C11/12)+(B12/C12/12)+(B22/C22/12)
Insert Your Business Name Here
Initial Required Funds
How much initial money do you require and what will it be used for?
Item
Amount
Depreciation
Advertising 204
Buildings 100,000 20 years
Decorating and Remodeling 10,000 7 years
Equipment 25,000 5 years
Furniture and Fixtures - 5 years
Insurance Premiums -
Legal and Accounting Fees 1,000
Licenses -
Real Estate -
Rent Deposits -
Salaries and Wages 80,000
Inventory -
Supplies -
Utility Deposits -
Vehicles - 5 years
Working Capital (Cash) -
Total Funds Required $ 216,204
Prepaid Expenses 81,204
=(B9/C9/12
Welcome!
Required Funds
Sources of Capital
Monthly Budget
Gross Mar
Edit
100%

FeatureEnvy2 with data.xlsx

Create report (PDF) | Export analysis (XLS)

Visualization | Characteristics | Sheets | Risks & Improve | Formulas | Constants | Compare

Summary | All Risks & Improve

Settings | Filter

Sheet	Cell	Risk	Level	Formula
Income Statement	C45	Incorrect formula location	▲	=('Required Funds'!B9/'Required Funds'!C9/12)...
Income Statement	C45	Referencing many different cell groups	▲	=('Required Funds'!B9/'Required Funds'!C9/12)...
Income Statement	E49	Fixed number	▲	=ABS(IPMT('Sources of Capital'!$B$22/12,3,'So...
Income Statement	F49	Fixed number	▲	=ABS(IPMT('Sources of Capital'!$B$22/12,4,'So...
Income Statement	G49	Fixed number	▲	=ABS(IPMT('Sources of Capital'!$B$22/12,5,'So...
Income Statement	H49	Fixed number	▲	=ABS(IPMT('Sources of Capital'!$B$22/12,6,'So...
Income Statement	I49	Fixed number	▲	=ABS(IPMT('Sources of Capital'!$B$22/12,7,'So...
Income Statement	J49	Fixed number	▲	=ABS(IPMT('Sources of Capital'!$B$22/12,8,'So...
Income Statement	K49	Fixed number	▲	=ABS(IPMT('Sources of Capital'!$B$22/12,9,'So...
Income Statement	M49	Fixed number	▲	=ABS(IPMT('Sources of Capital'!$B$22/12,11,'S...
Sources of Capital	B26	Fixed number	▲	=B7*0.8
Sources of Capital	B13	Fixed number	▲	=B8*0.2
Financial Diagnostics	E16	Fixed number	▲	=IF(C16<0.09,"Interest rate may be too low for ...
Financial Diagnostics	E17	Fixed number	▲	=IF(C17>120,"Loan term may be too high for thi...
Financial Diagnostics	E19	Fixed number	▲	=IF(C19<0.07,"Interest rate may be too low for ...
Financial Diagnostics	E20	Fixed number	▲	=IF(C20>240,"Loan term may be too high for thi...
Financial Diagnostics	E22	Fixed number	▲	=IF(C22>0.1,"Calculated loan payments as a per...
Financial Diagnostics	E29	Fixed number	▲	=IF(C29<0.02,"Advertising as a percent of sales ...

FeatureEnvy2 with data.xlsx

Create report (PDF) | Export analysis (XLS)

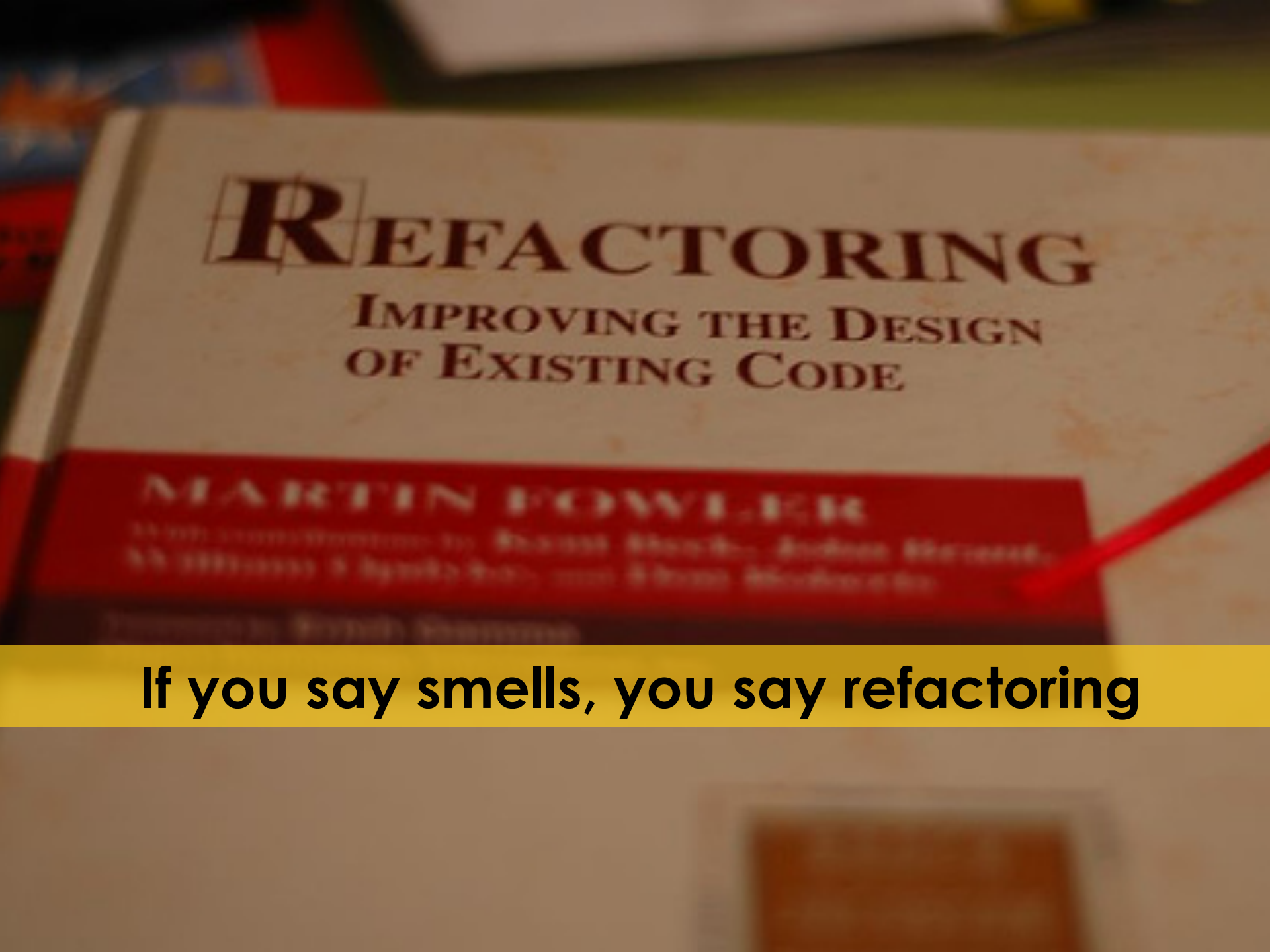
Visualization | Characteristics | Sheets | Risks & Improve | Formulas | Constants | Compare

Summary | All Risks & Improve

Settings | Filter

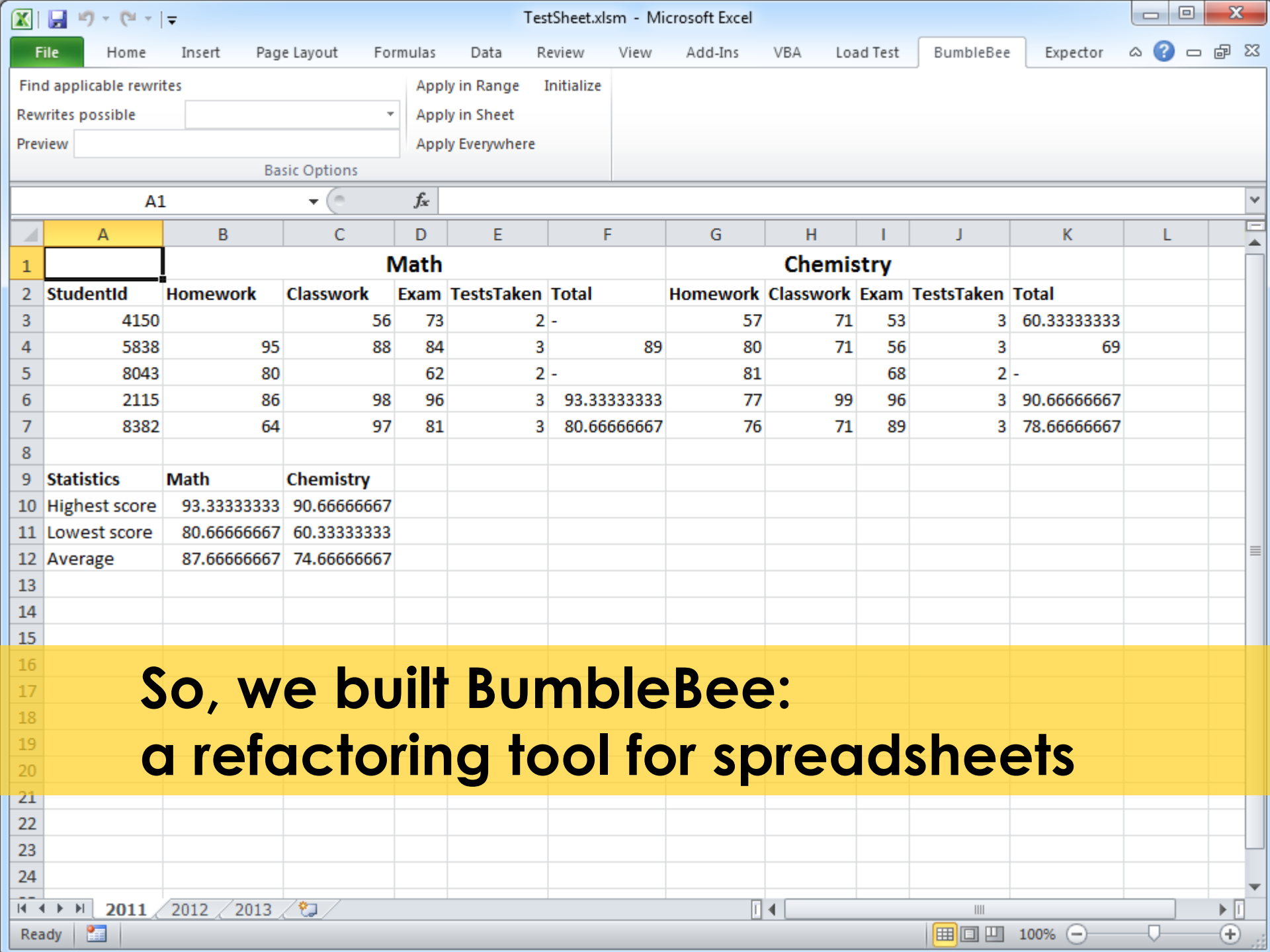
Sheet	Cell	Risk	Level	Formula
Income Statement	C45	Incorrect formula location	▲	=('Required Funds'!B9/'Required Funds'!C9/12)...
What's going on?				
There are 10 more references to worksheet Required Funds than references to the current worksheet. This makes the formula unreadable because the values it depends on are not apparent.				
Improvement suggestion				
Move this formula to Required Funds.				
Full formula				
=('Required Funds'!B9/'Required Funds'!C9/12)+('Required Funds'!B10/'Required Funds'!C10/12)+('Required Funds'!B11/'Required Funds'!C11/12)+('Required Funds'!B12/'Required Funds'!C12/12)+('Required Funds'!B22/'Required Funds'!C22/12)				
The calculated result of this formula is:				
952.4				
Income Statement	C45	Referencing many different cell groups	▲	=('Required Funds'!B9/'Required Funds'!C9/12)...
Income Statement	E49	Fixed number	▲	=ABS(IPMT('Sources of Capital'!$B$22/12,3,'So...
Income Statement	F49	Fixed number	▲	=ABS(IPMT('Sources of Capital'!$B$22/12,4,'So...
Income Statement	G49	Fixed number	▲	=ABS(IPMT('Sources of Capital'!$B$22/12,5,'So...
Income Statement	H49	Fixed number	▲	=ABS(IPMT('Sources of Capital'!$B$22/12,6,'So...
Income Statement	I49	Fixed number	▲	=ABS(IPMT('Sources of Capital'!$B$22/12,7,'So...
Income Statement	J49	Fixed number	▲	=ABS(IPMT('Sources of Capital'!$B$22/12,8,'So...
Income Statement	K49	Fixed number	▲	=ABS(IPMT('Sources of Capital'!$B$22/12,9,'So...
Income Statement	M49	Fixed number	▲	=ABS(IPMT('Sources of Capital'!$B$22/12,11,'S...


If you say smells, you say…

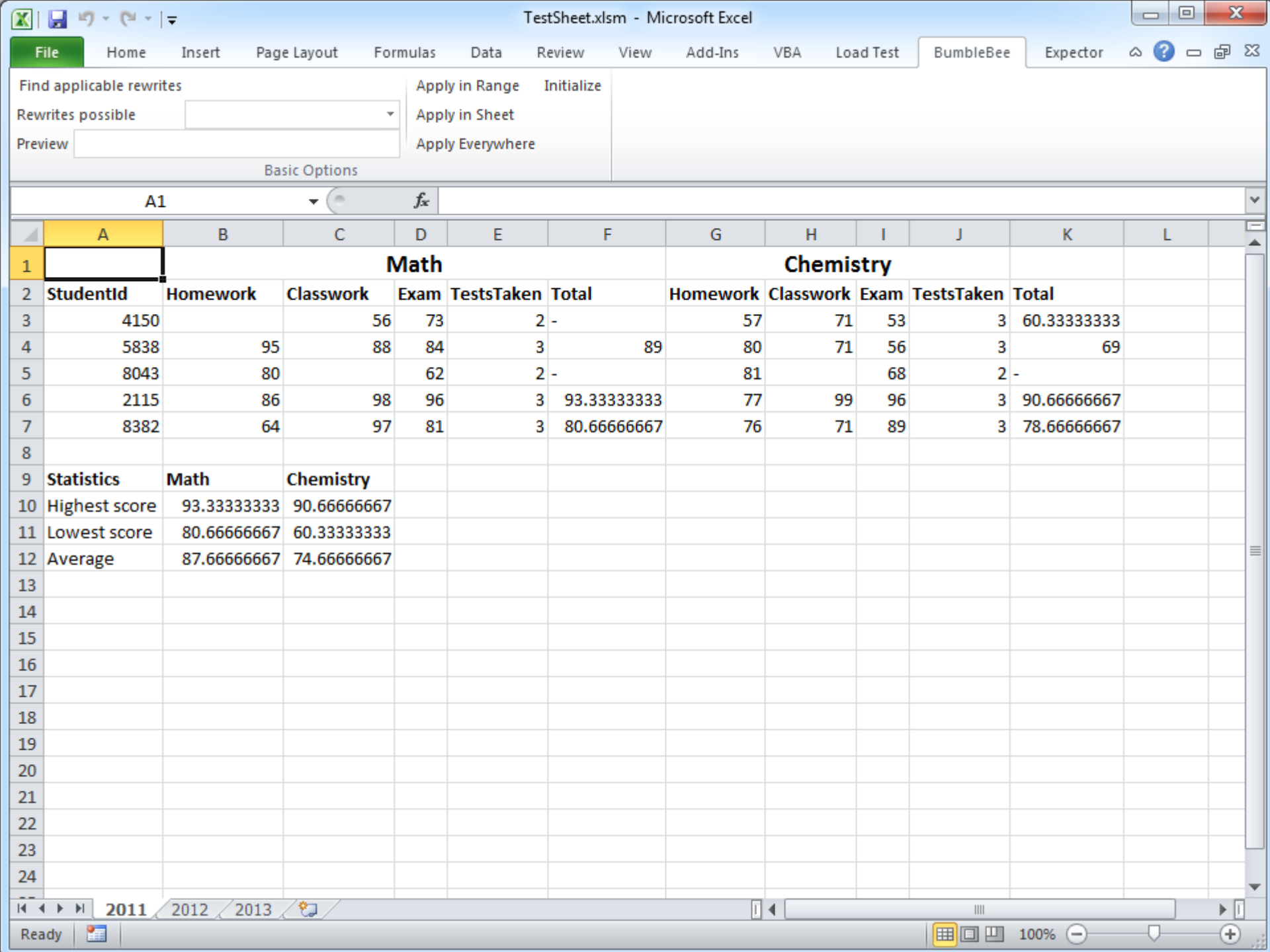


If you say smells, you say refactoring

So, we built BumbleBee: a refactoring tool for spreadsheets



So, we built BumbleBee: a refactoring tool for spreadsheets


TestSheet.xlsm - Microsoft Excel
File
Home
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Page Layout
Formulas
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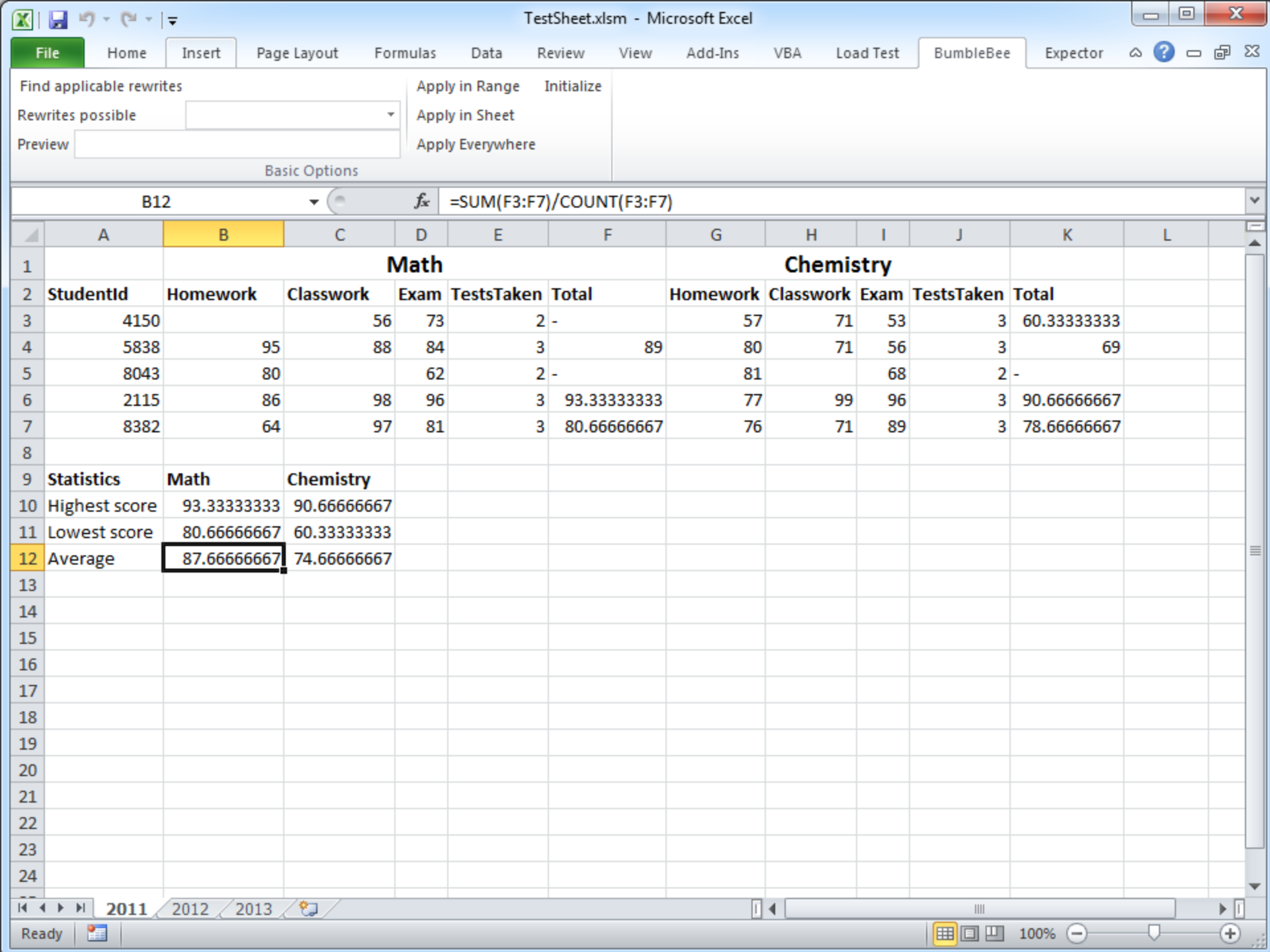
Load Test
BumbleBee
Expector
Find applicable rewrites
Rewrites possible
Preview
Basic Options
Apply in Range
Initialize
Apply in Sheet
Apply Everywhere
A1
Math
Chemistry
StudentId
Homework
Classwork
Exam
TestsTaken
Total
4150 - 56 73 2 - 57 71 53 3 60.33333333
5838 95 88 84 3 89 80 71 56 3 69
8043 80 62 2 - 81 68 2 -
2115 86 98 96 3 93.33333333 77 99 96 3 90.66666667
8382 64 97 81 3 80.66666667 76 71 89 3 78.66666667
Statistics
Math
Chemistry
Highest score 93.33333333 90.66666667
Lowest score 80.66666667 60.33333333
Average 87.66666667 74.66666667
2011
2012
2013
Ready
100%



	A	B	C	D	E	F	G	H	I	J	K	L
1		Math					Chemistry					
2	StudentId	Homework	Classwork	Exam	TestsTaken	Total	Homework	Classwork	Exam	TestsTaken	Total	
3	4150		56	73	2	-	57	71	53	3	60.33333333	
4	5838	95	88	84	3	89	80	71	56	3	69	
5	8043	80		62	2	-	81		68	2	-	
6	2115	86	98	96	3	93.33333333	77	99	96	3	90.66666667	
7	8382	64	97	81	3	80.66666667	76	71	89	3	78.66666667	
8												
9	Statistics	Math	Chemistry									
10	Highest score	93.33333333	90.66666667									
11	Lowest score	80.66666667	60.33333333									
12	Average	87.66666667	74.66666667									
13												
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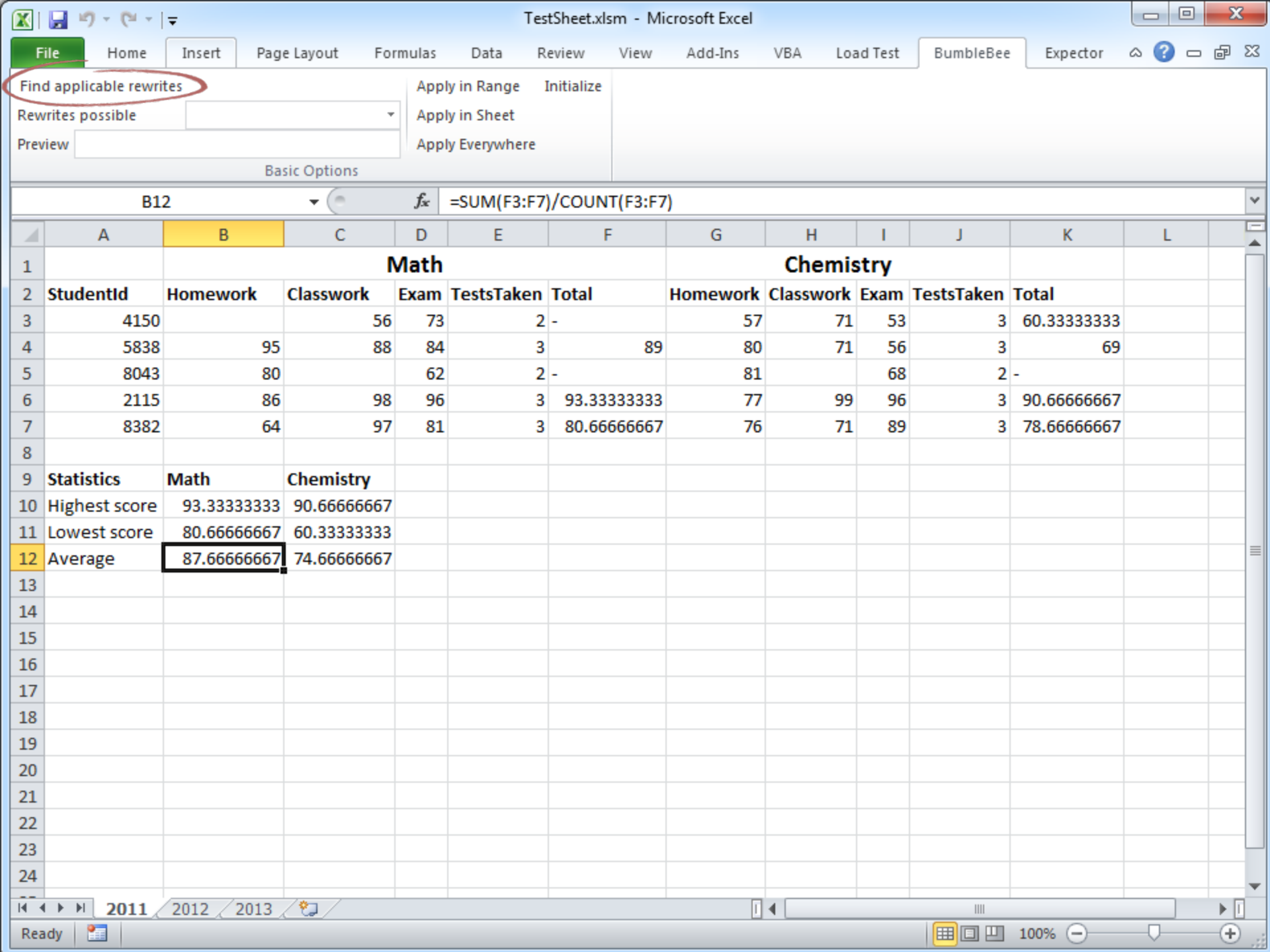
24												



	A	B	C	D	E	F	G	H	I	J	K	L
1		Math					Chemistry					
2	StudentId	Homework	Classwork	Exam	TestsTaken	Total	Homework	Classwork	Exam	TestsTaken	Total	
3	4150		56	73	2	-	57	71	53	3	60.33333333	
4	5838	95	88	84	3	89	80	71	56	3	69	
5	8043	80		62	2	-	81		68	2	-	
6	2115	86	98	96	3	93.33333333	77	99	96	3	90.66666667	
7	8382	64	97	81	3	80.66666667	76	71	89	3	78.66666667	
8												
9	Statistics	Math	Chemistry									
10	Highest score	93.33333333	90.66666667									
11	Lowest score	80.66666667	60.33333333									
12	Average	87.66666667	74.66666667									
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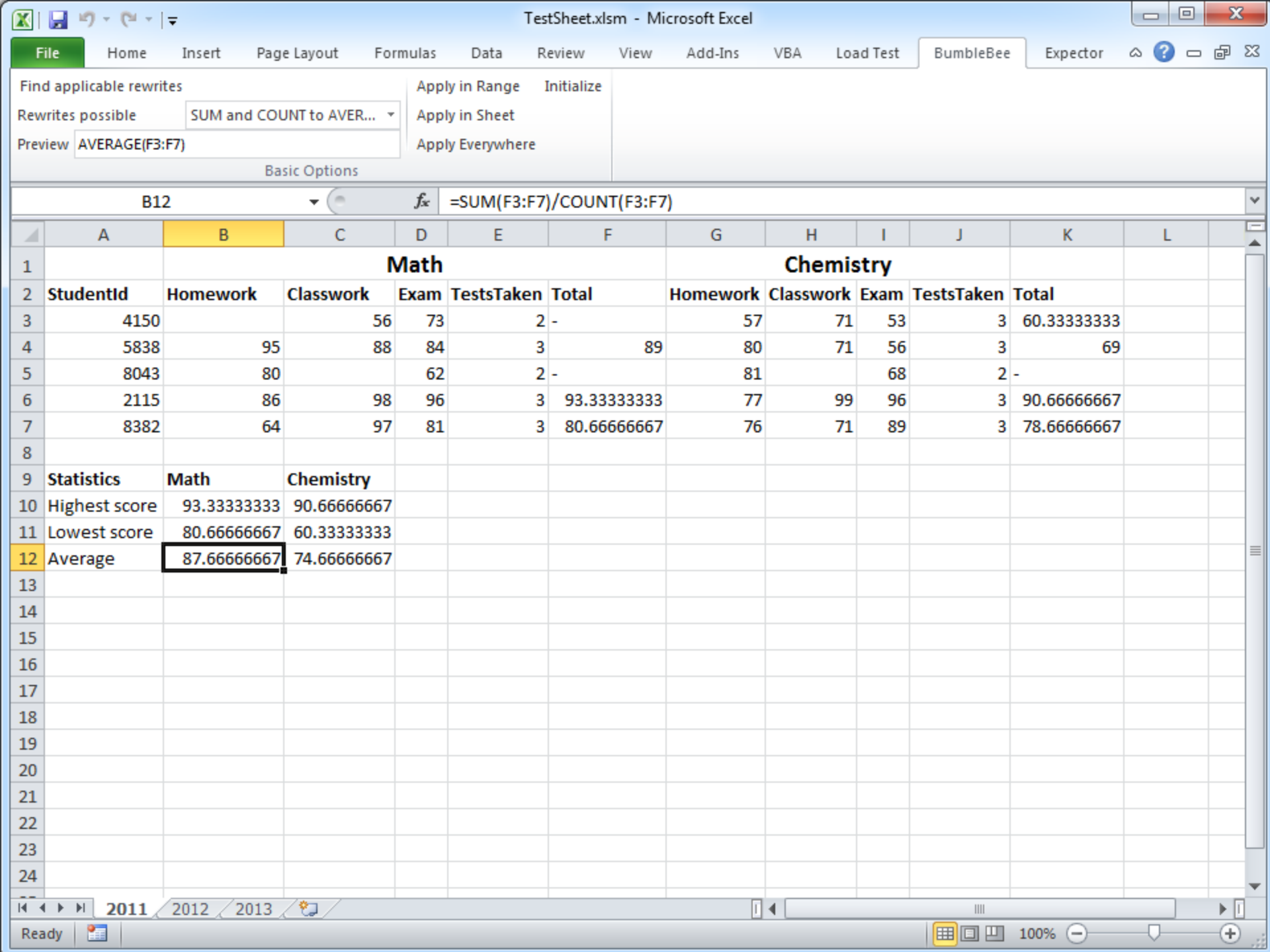
24												


TestSheet.xlsm - Microsoft Excel
File
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BumbleBee
Expector
Find applicable rewrites
Rewrites possible
SUM and COUNT to AVER...
Preview
AVERAGE(F3:F7)
Basic Options
Apply in Range
Initialize
Apply in Sheet
Apply Everywhere
B12
=SUM(F3:F7)/COUNT(F3:F7)
Math
Chemistry
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Homework
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TestsTaken
Total
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5838
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2115
8382
Statistics
Highest score
Lowest score
Average
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80.66666667
87.66666667
90.66666667
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74.66666667
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2012
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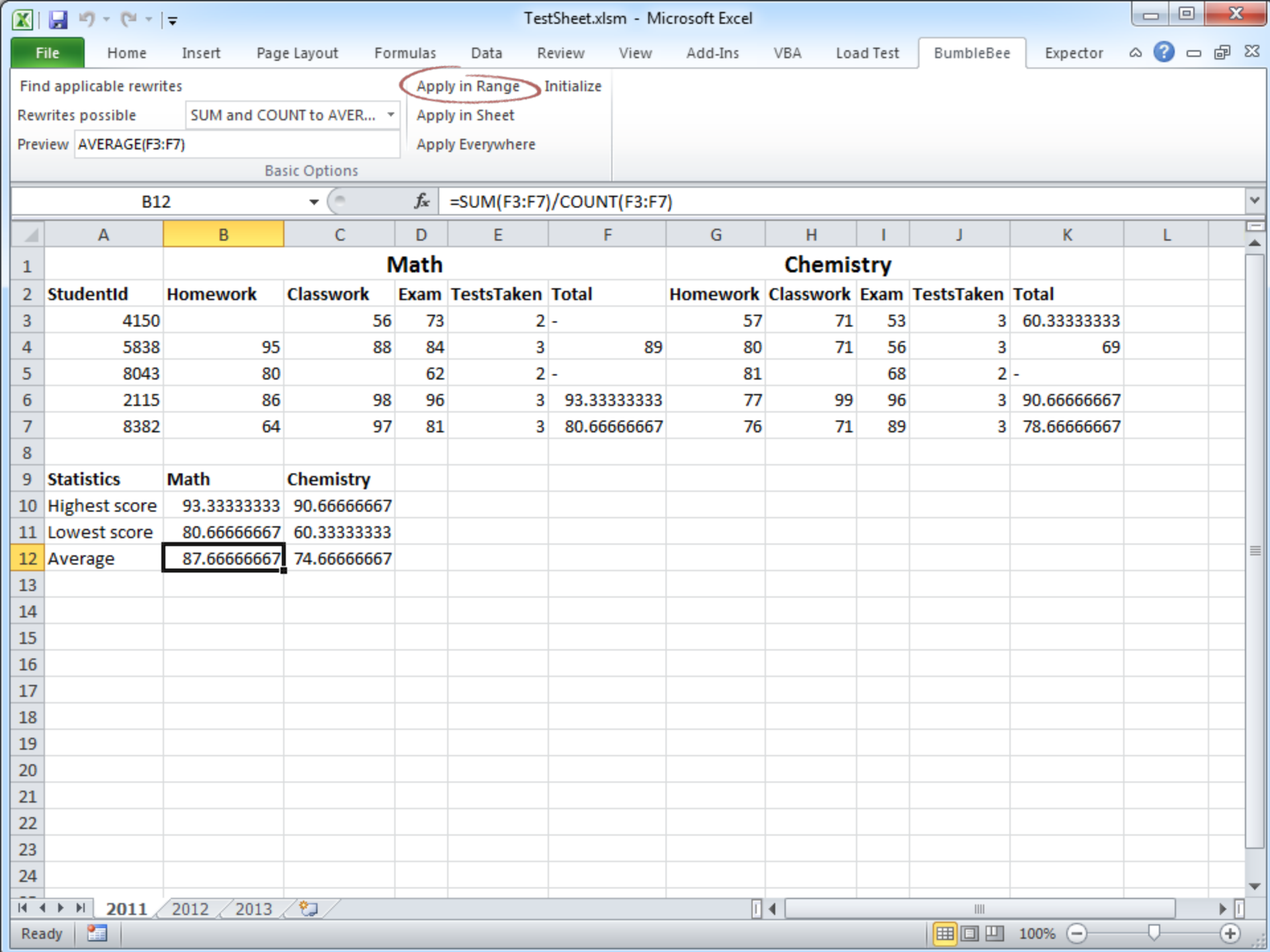
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4150 56 73 2 - 57 71 53 3 60.33333333
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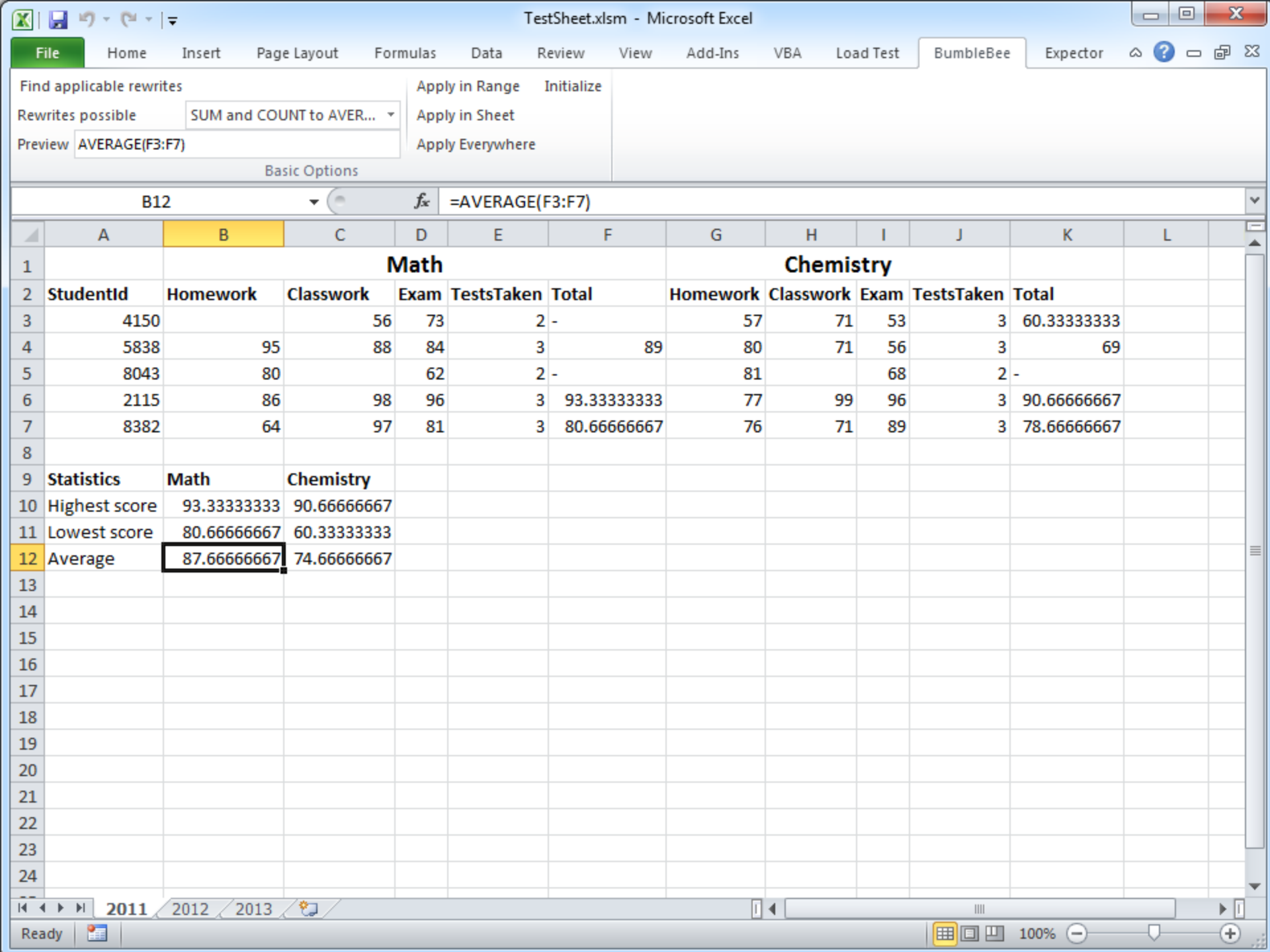
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Math
Chemistry
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Average 87.66666667 74.66666667
2011
2012
2013
Ready
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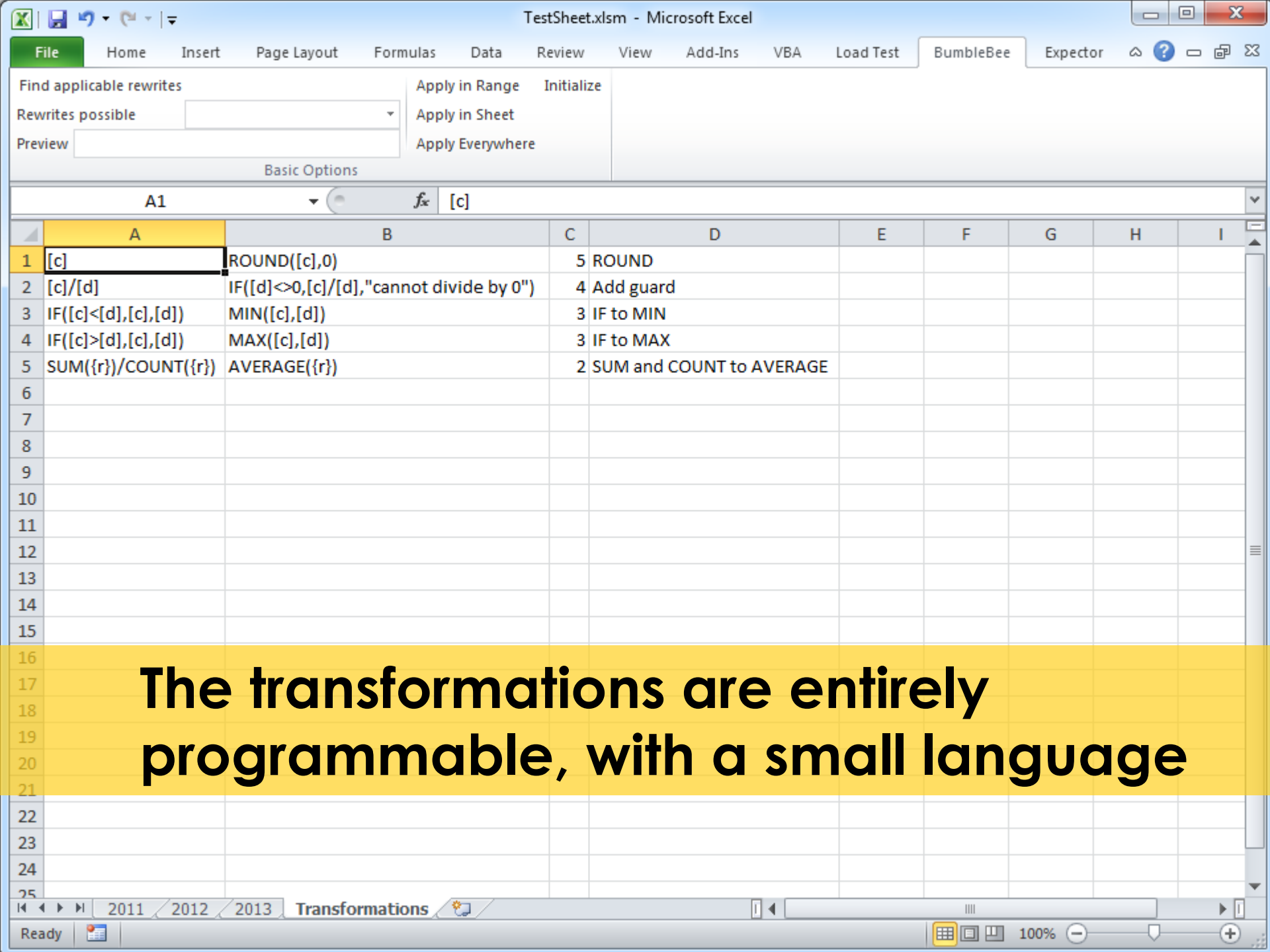
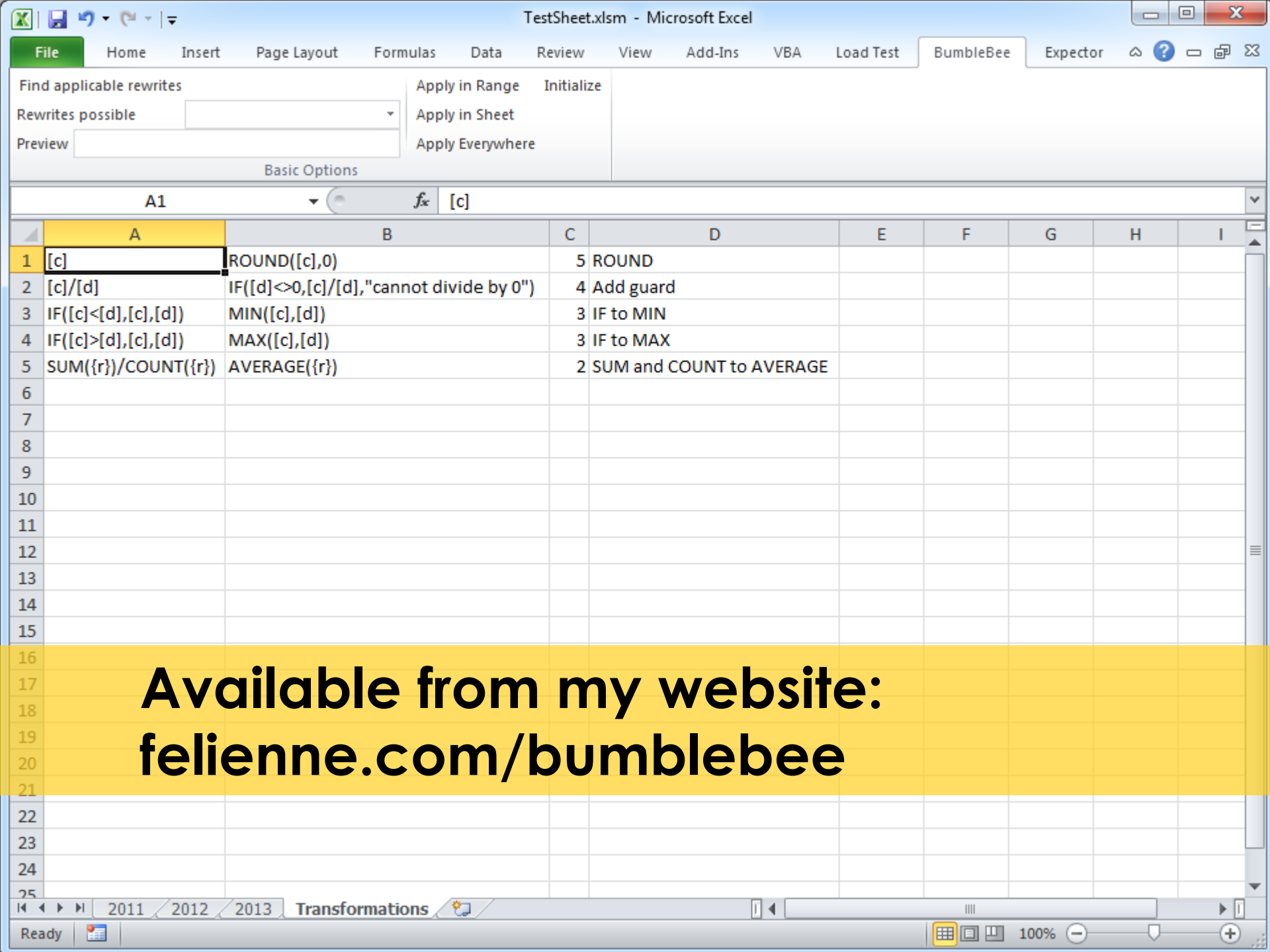


The transformations are entirely programmable, with a small language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Expector
Find applicable rewrites
Rewrites possible
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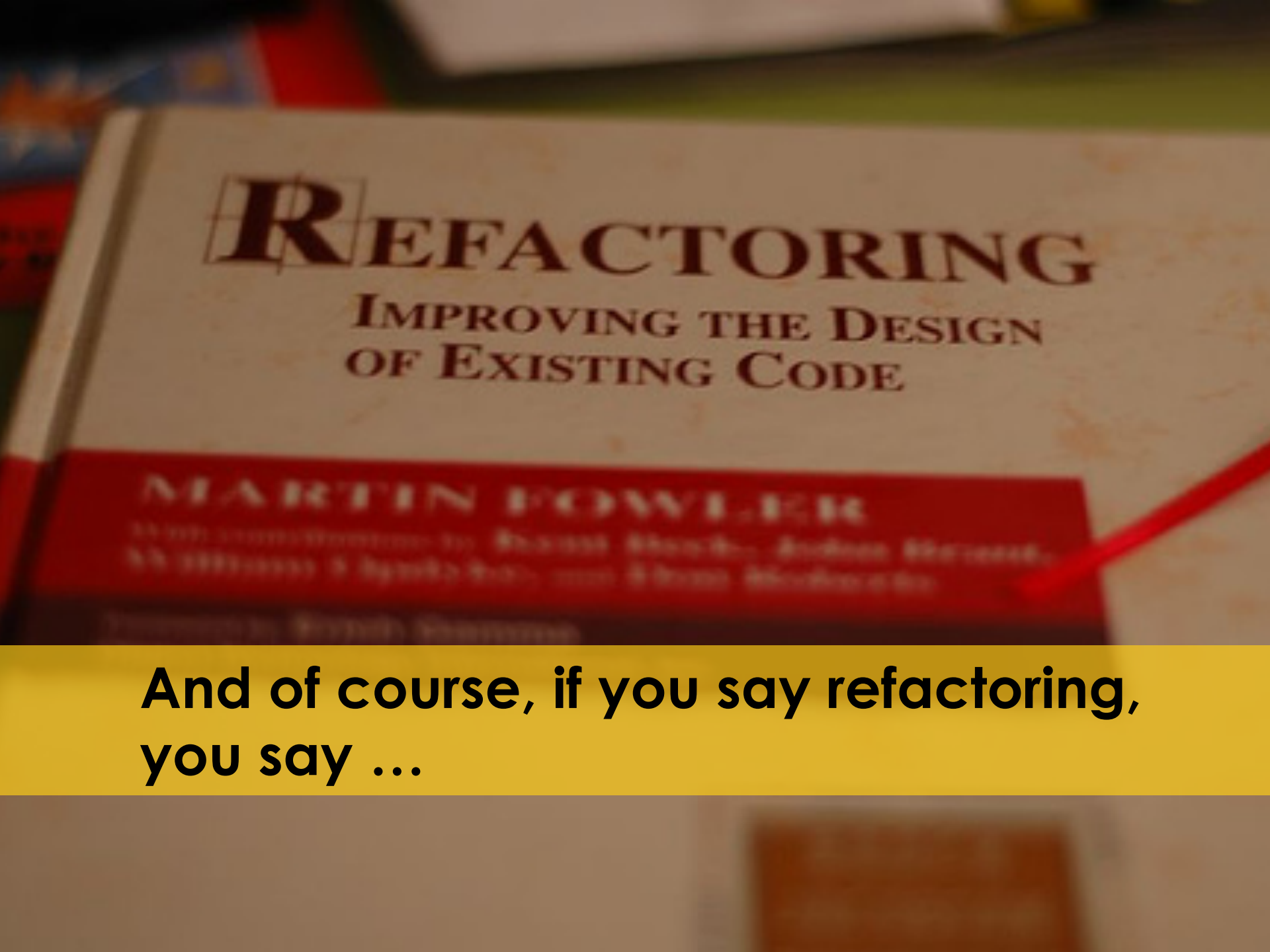
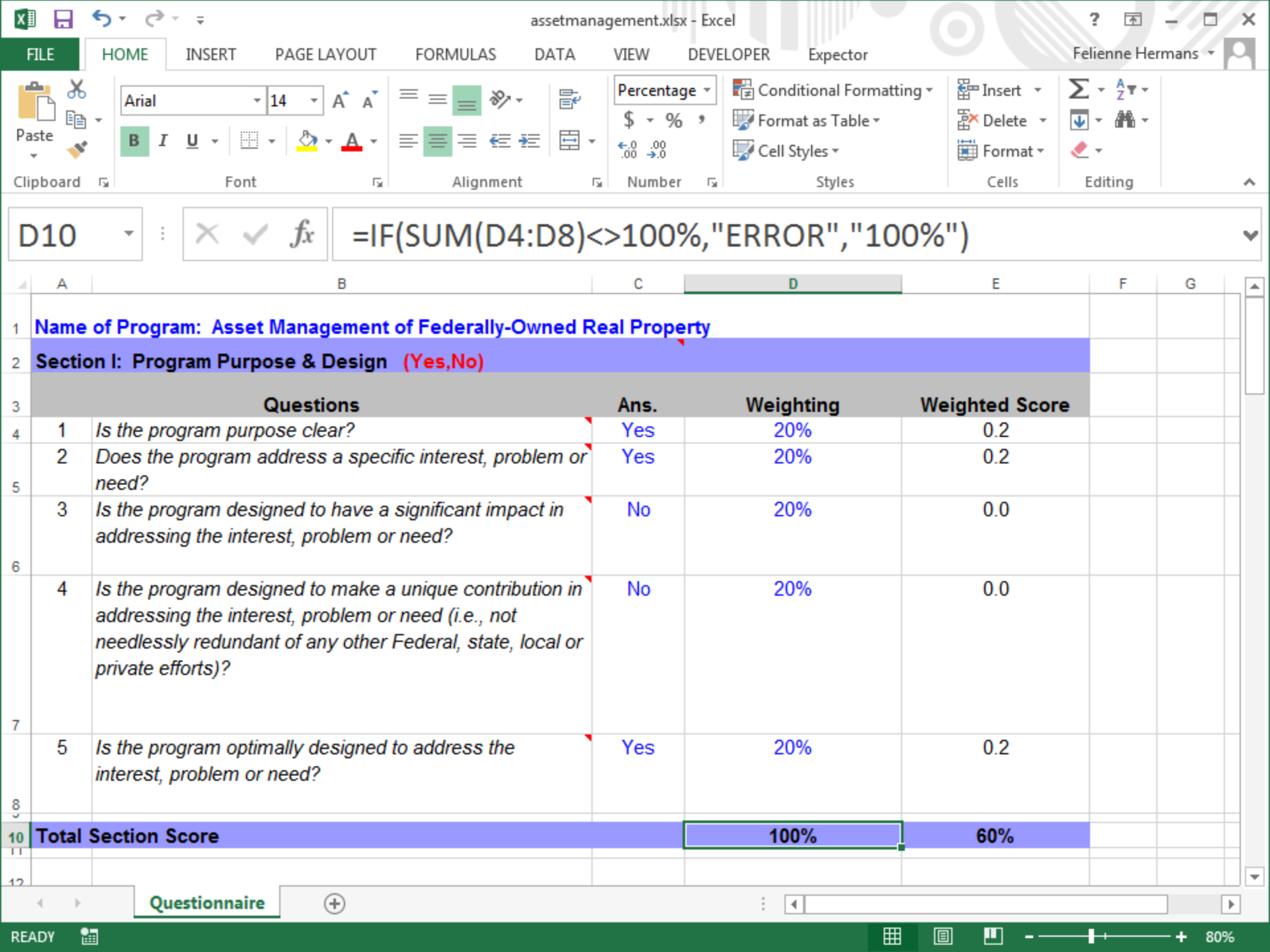
Basic Options
Apply in Range
Initialize
Apply in Sheet
Apply Everywhere
A1
[c]
A
B
C
D
E
F
G
H
I
1 [c] ROUND([c],0) 5 ROUND
2 [c]/[d] IF([d]<>0,[c]/[d],"cannot divide by 0") 4 Add guard
3 IF([c]<[d],[c],[d]) MIN([c],[d]) 3 IF to MIN
4 IF([c]>[d],[c],[d]) MAX([c],[d]) 3 IF to MAX
5 SUM({r})/COUNT({r}) AVERAGE({r}) 2 SUM and COUNT to AVERAGE
Available from my website:
felienne.com/bumblebee
2011
2012
2013
Transformations
Ready
100%



And of course, if you say refactoring, you say …

And of course, if you say refactoring, you say testing


assetmanagement.xlsx - Excel
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Expector
Felienne Hermans
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Arial
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Format as Table
Cell Styles
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Delete
Format
Clipboard
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Alignment
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Styles
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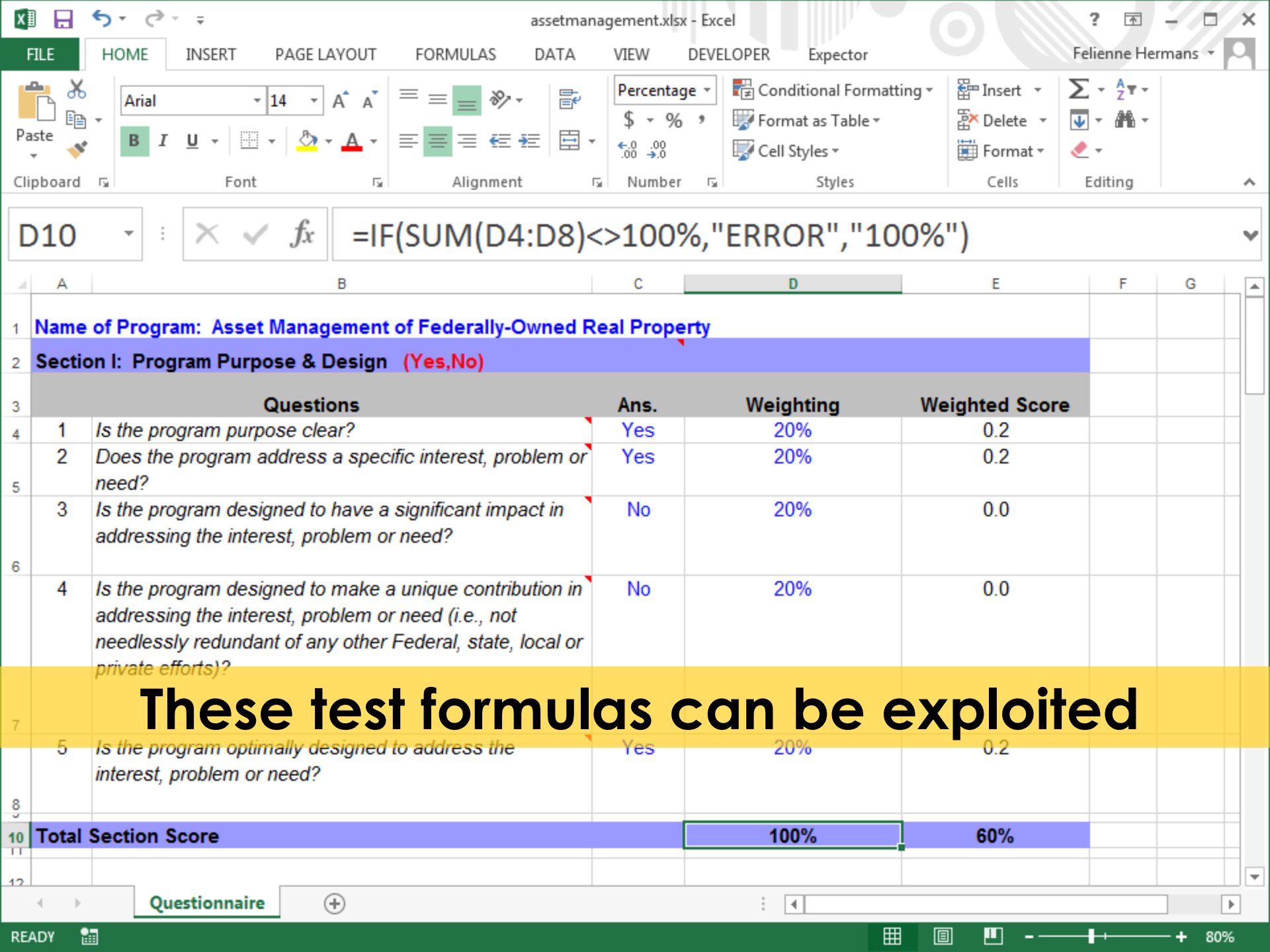
Editing
D10
=IF(SUM(D4:D8)<>100%,"ERROR","100%")
Name of Program: Asset Management of Federally-Owned Real Property
Section I: Program Purpose & Design (Yes,No)
Questions
Ans.
Weighting
Weighted Score
1 Is the program purpose clear? Yes 20% 0.2
2 Does the program address a specific interest, problem or need? Yes 20% 0.2
3 Is the program designed to have a significant impact in addressing the interest, problem or need? No 20% 0.0
4 Is the program designed to make a unique contribution in addressing the interest, problem or need (i.e., not needlessly redundant of any other Federal, state, local or private efforts)? No 20% 0.0
5 Is the program optimally designed to address the interest, problem or need? Yes 20% 0.2
Total Section Score 100% 60%
Questionnaire
READY
80%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Felienne Hermans
Paste
Arial
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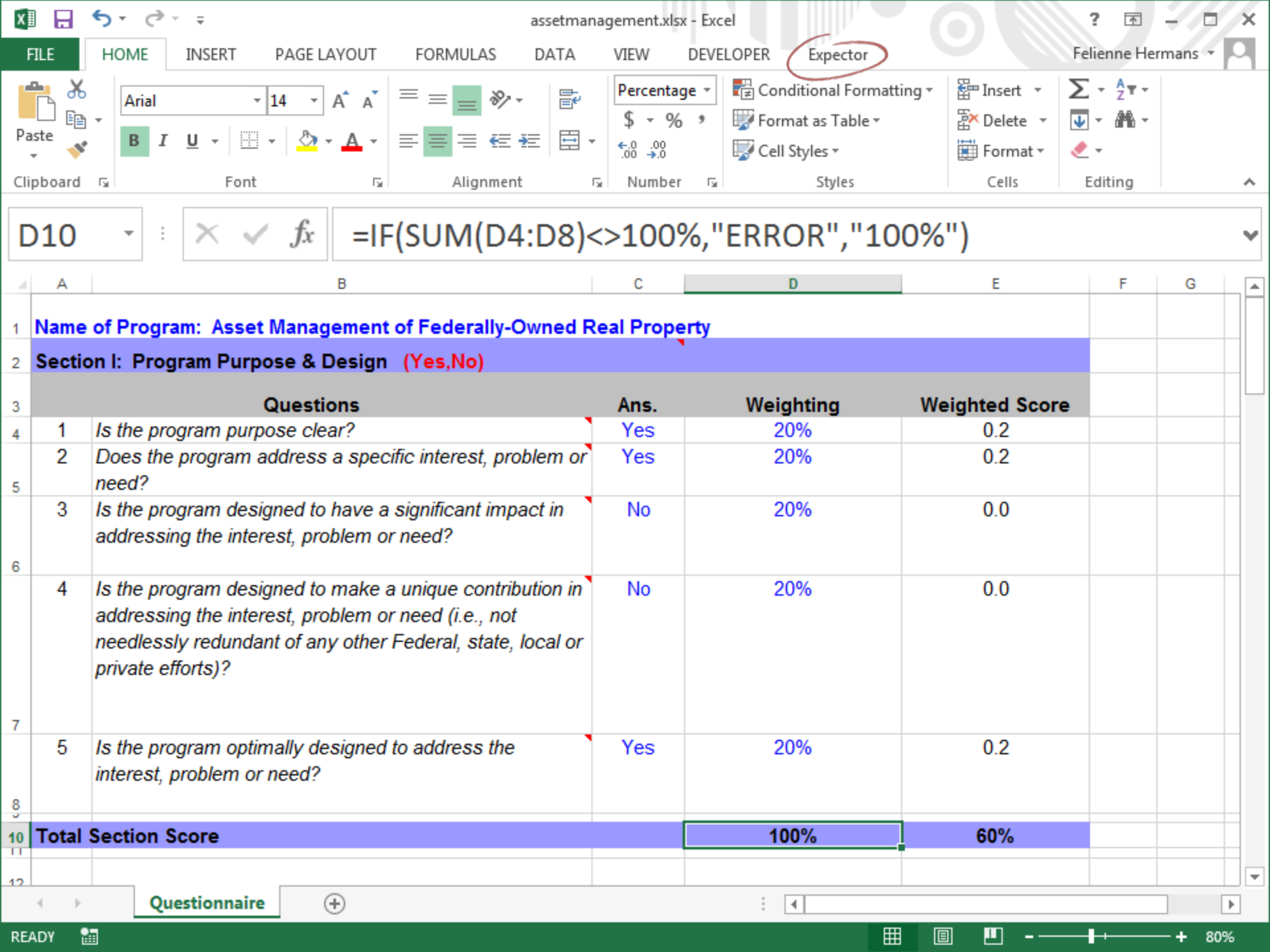
Format as Table
Cell Styles
Insert
Delete
Format
Clipboard
Font
Alignment
Number
Styles
Cells
Editing
D10
=IF(SUM(D4:D8)<>100%,"ERROR","100%")
Name of Program: Asset Management of Federally-Owned Real Property
Section I: Program Purpose & Design (Yes,No)
Questions
Ans.
Weighting
Weighted Score
1 Is the program purpose clear? Yes 20% 0.2
2 Does the program address a specific interest, problem or need? Yes 20% 0.2
3 Is the program designed to have a significant impact in addressing the interest, problem or need? No 20% 0.0
4 Is the program designed to make a unique contribution in addressing the interest, problem or need (i.e., not needlessly redundant of any other Federal, state, local or private efforts)? No 20% 0.0
These test formulas can be exploited
5 Is the program optimally designed to address the interest, problem or need? Yes 20% 0.2
Total Section Score 100% 60%
Questionnaire
READY
80%


assetmanagement.xlsx - Excel
FILE
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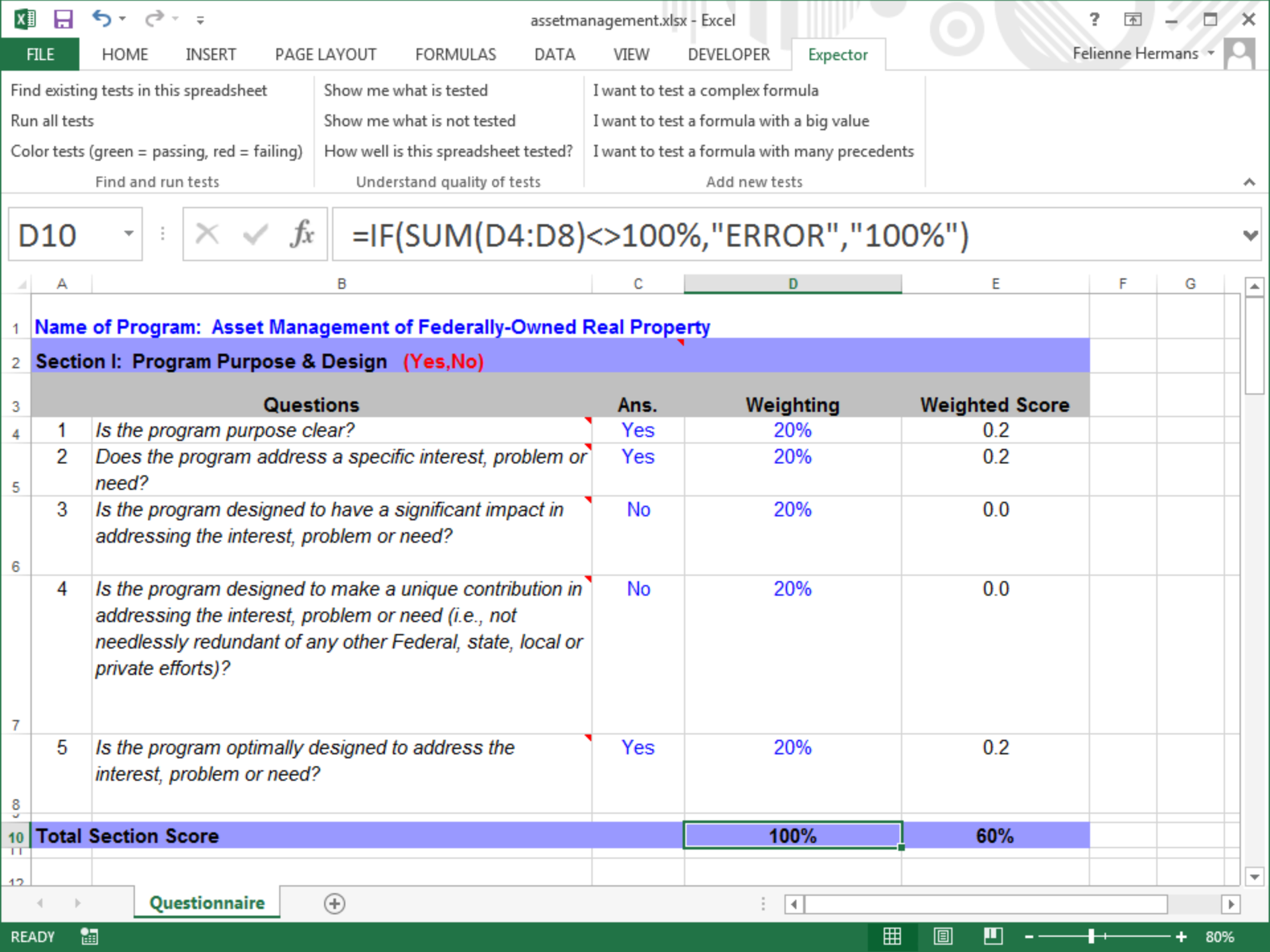
INSERT
PAGE LAYOUT
FORMULAS
DATA
VIEW
DEVELOPER
Expector
Felienne Hermans
Paste
Arial
14
Percentage
Conditional Formatting
Format as Table
Cell Styles
Insert
Delete
Format
Clipboard
Font
Alignment
Number
Styles
Cells
Editing
D10
=IF(SUM(D4:D8)<>100%,"ERROR","100%")
Name of Program: Asset Management of Federally-Owned Real Property
Section I: Program Purpose & Design (Yes,No)
Questions
Ans.
Weighting
Weighted Score
1 Is the program purpose clear? Yes 20% 0.2
2 Does the program address a specific interest, problem or need? Yes 20% 0.2
3 Is the program designed to have a significant impact in addressing the interest, problem or need? No 20% 0.0
4 Is the program designed to make a unique contribution in addressing the interest, problem or need (i.e., not needlessly redundant of any other Federal, state, local or private efforts)? No 20% 0.0
5 Is the program optimally designed to address the interest, problem or need? Yes 20% 0.2
Total Section Score 100% 60%
Questionnaire
READY
80%


assetmanagement.xlsx - Excel
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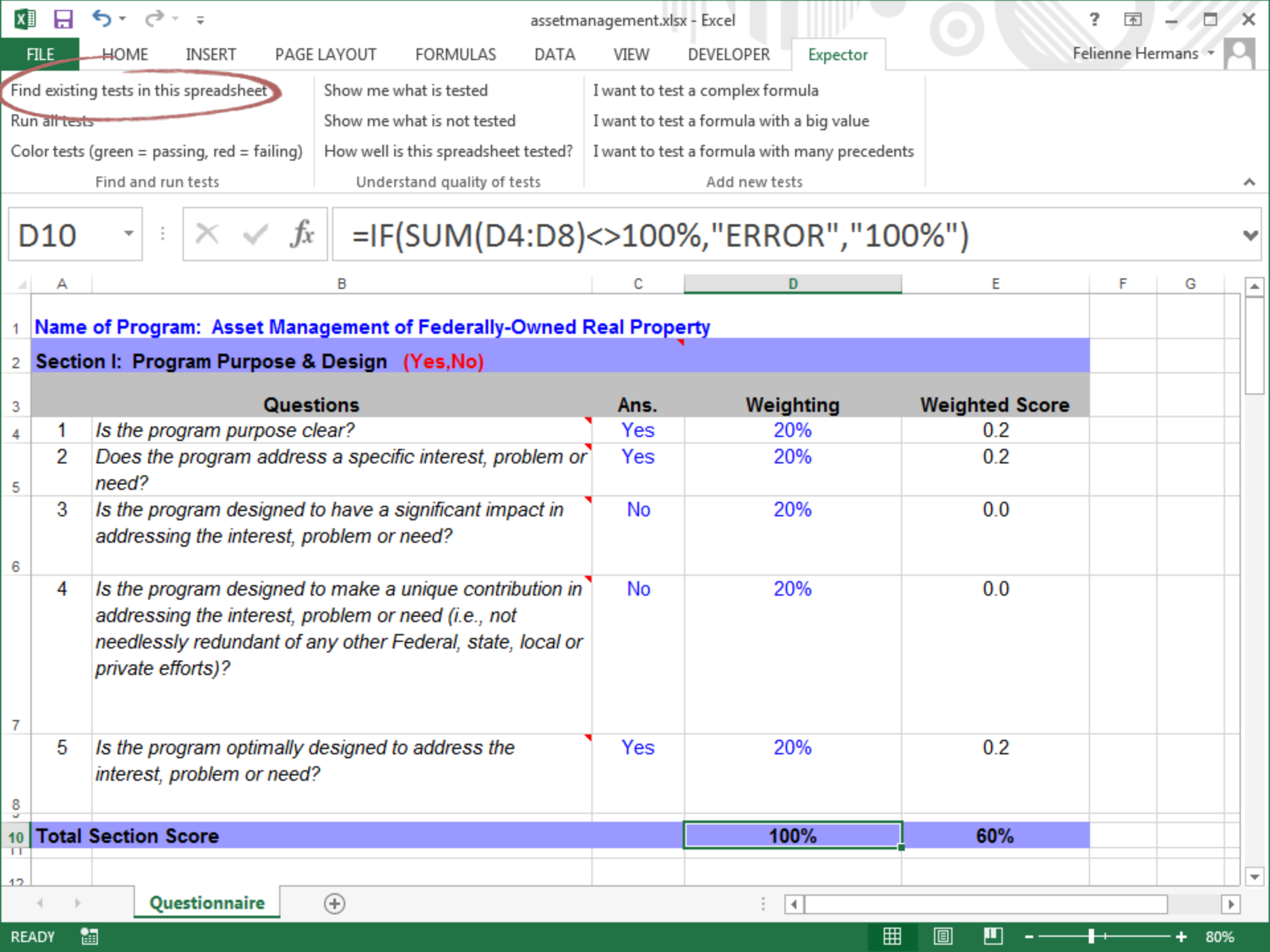
DEVELOPER
Expector
Felienne Hermans
Find existing tests in this spreadsheet
Run all tests
Color tests (green = passing, red = failing)
Find and run tests
Show me what is tested
Show me what is not tested
How well is this spreadsheet tested?
Understand quality of tests
I want to test a complex formula
I want to test a formula with a big value
I want to test a formula with many precedents
Add new tests
D10
=IF(SUM(D4:D8)<>100%,"ERROR","100%")
Name of Program: Asset Management of Federally-Owned Real Property
Section I: Program Purpose & Design (Yes,No)
Questions
Ans.
Weighting
Weighted Score
1 Is the program purpose clear? Yes 20% 0.2
2 Does the program address a specific interest, problem or need? Yes 20% 0.2
3 Is the program designed to have a significant impact in addressing the interest, problem or need? No 20% 0.0
4 Is the program designed to make a unique contribution in addressing the interest, problem or need (i.e., not needlessly redundant of any other Federal, state, local or private efforts)? No 20% 0.0
5 Is the program optimally designed to address the interest, problem or need? Yes 20% 0.2
Total Section Score 100% 60%
Questionnaire
READY
80%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PAGE LAYOUT
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Ans.
Weighting
Weighted Score
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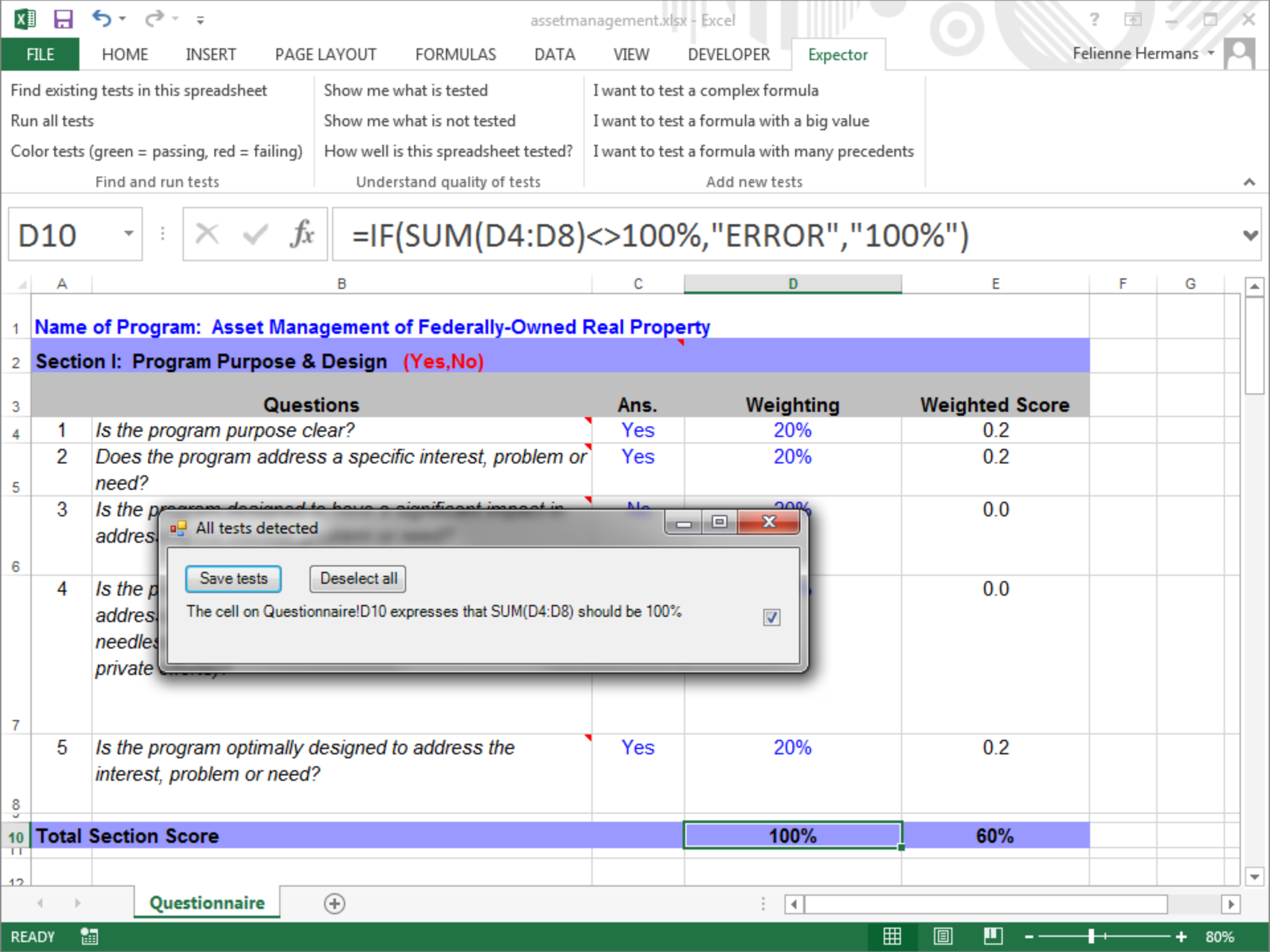
5 Is the program optimally designed to address the interest, problem or need? Yes 20% 0.2
Total Section Score 100% 60%
Questionnaire
READY
80%


assetmanagement.xlsx - Excel
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Add new tests
D10
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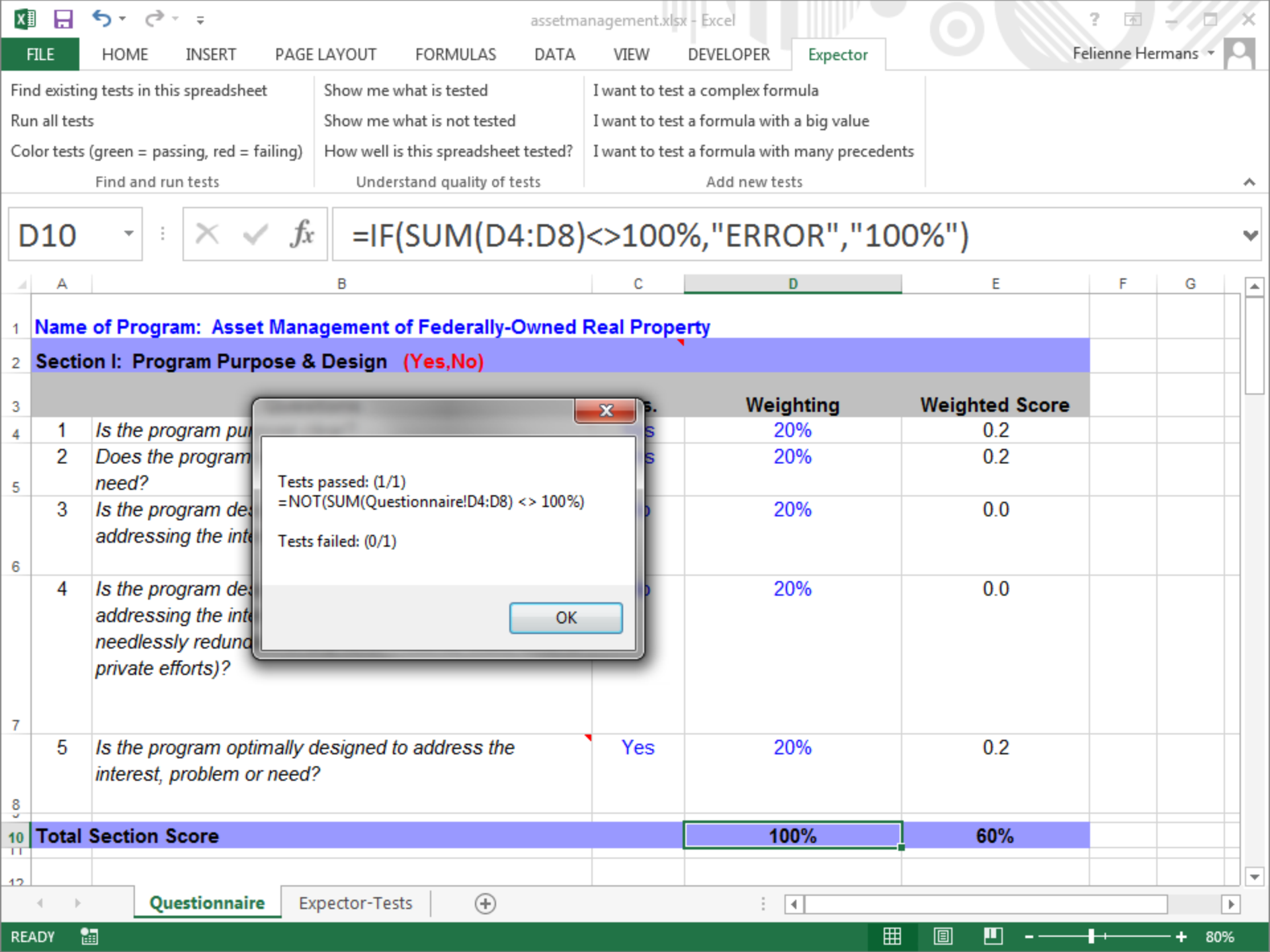
Name of Program: Asset Management of Federally-Owned Real Property
Section I: Program Purpose & Design (Yes,No)
Questions
Ans.
Weighting
Weighted Score
1 Is the program purpose clear? Yes 20% 0.2
2 Does the program address a specific interest, problem or need? Yes 20% 0.2
3 0.0
4 0.0
5 Is the program optimally designed to address the interest, problem or need? Yes 20% 0.2
Total Section Score 100% 60%
All tests detected
Save tests
Deselect all
The cell on Questionnaire!D10 expresses that SUM(D4:D8) should be 100%
Questionnaire
READY
80%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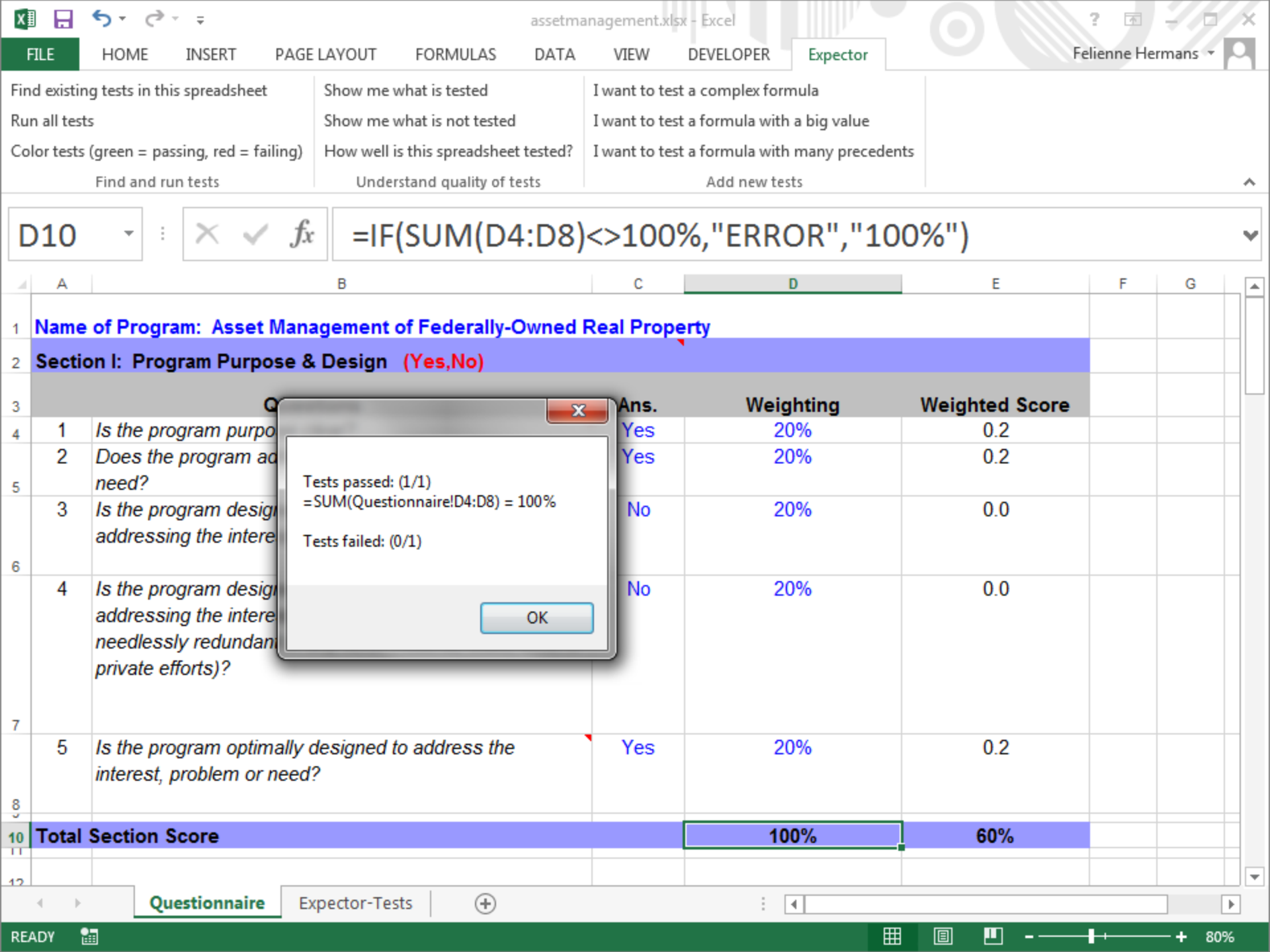
Add new tests
D10
=IF(SUM(D4:D8)<>100%,"ERROR","100%")
Name of Program: Asset Management of Federally-Owned Real Property
Section I: Program Purpose & Design (Yes,No)
Weighting
Weighted Score
1 Is the program pu
20%
0.2
2 Does the program
need?
20%
0.2
3 Is the program des
addressing the inte
20%
0.0
4 Is the program des
addressing the inte
needlessly reduno
private efforts)?
20%
0.0
5 Is the program optimally designed to address the interest, problem or need?
Yes
20%
0.2
Total Section Score
100%
60%
Tests passed: (1/1)
=NOT(SUM(Questionnaire!D4:D8) <> 100%)
Tests failed: (0/1)
OK
Questionnaire
Expector-Tests
READY
80%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D10
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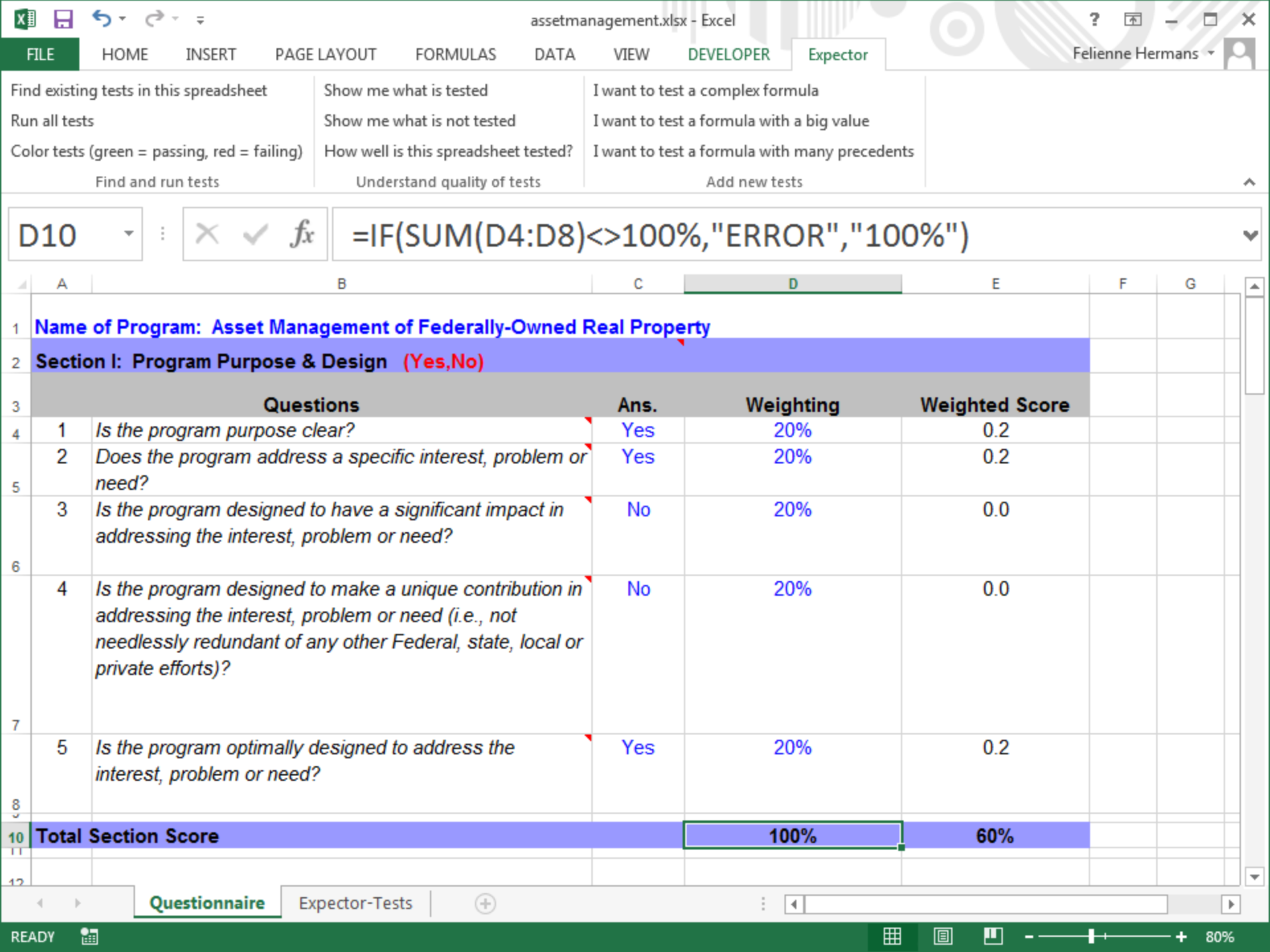
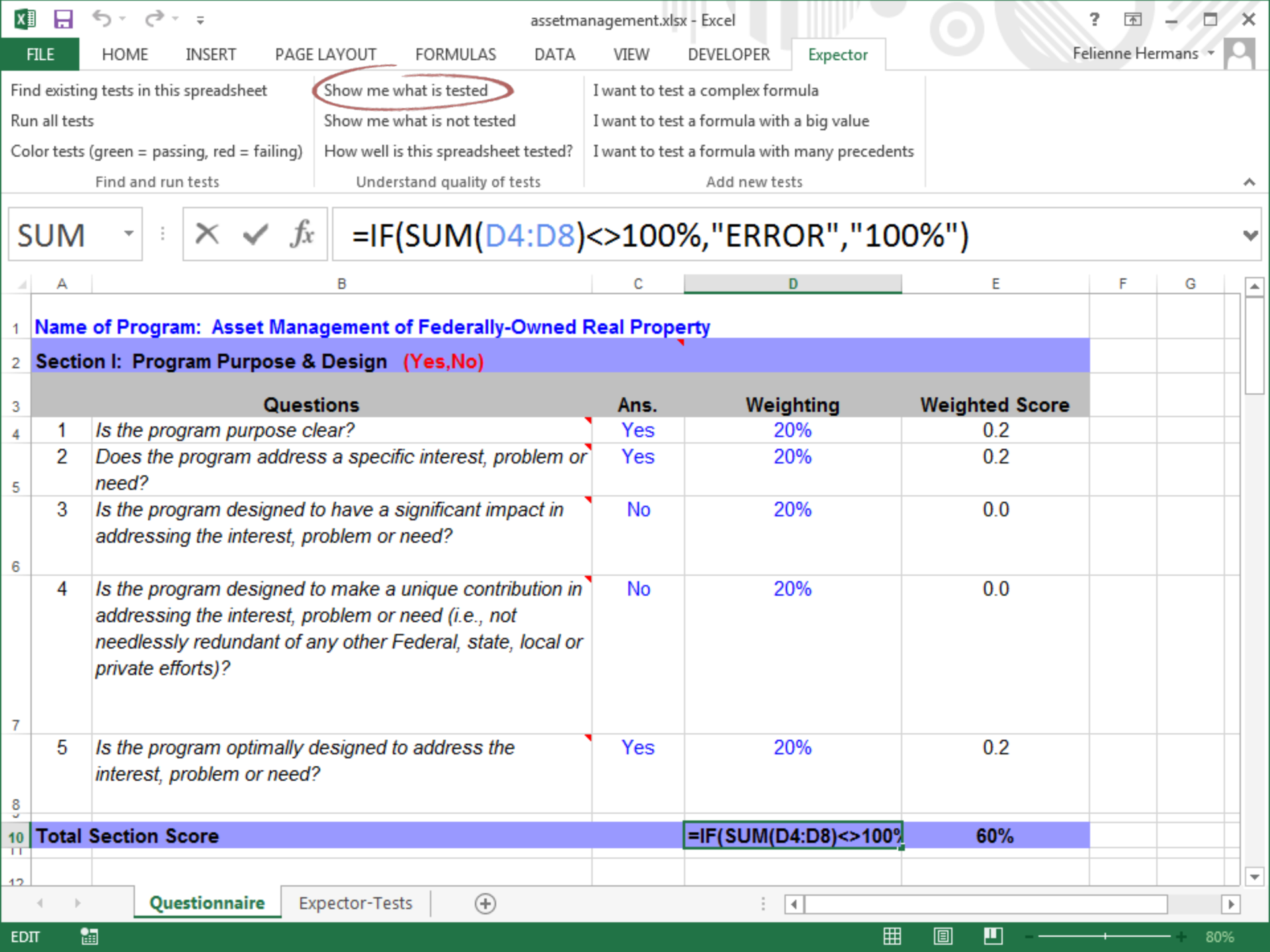
Name of Program: Asset Management of Federally-Owned Real Property
Section I: Program Purpose & Design (Yes,No)
Ans.
Weighting
Weighted Score
1
Is the program purpo
Yes
20%
0.2
2
Does the program ad
need?
Yes
20%
0.2
3
Is the program desig
addressing the intere
No
20%
0.0
4
Is the program desig
addressing the intere
needlessly redundan
private efforts)?
No
20%
0.0
5
Is the program optimally designed to address the interest, problem or need?
Yes
20%
0.2
Total Section Score
100%
60%
Tests passed: (1/1)
=SUM(Questionnaire!D4:D8) = 100%
Tests failed: (0/1)
OK
Questionnaire
Expector-Tests
READY
80%



Name of Program: Asset Management of Federally-Owned Real Property

Section I: Program Purpose & Design (Yes,No)

	Questions	Ans.	Weighting	Weighted Score
1	*Is the program purpose clear?*	Yes	20%	0.2
2	*Does the program address a specific interest, problem or need?*	Yes	20%	0.2
3	*Is the program designed to have a significant impact in addressing the interest, problem or need?*	No	20%	0.0
4	*Is the program designed to make a unique contribution in addressing the interest, problem or need (i.e., not needlessly redundant of any other Federal, state, local or private efforts)?*	No	20%	0.0
5	*Is the program optimally designed to address the interest, problem or need?*	Yes	20%	0.2
Total Section Score			**100%**	**60%**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How well is this spreadsheet tested?
Understand quality of tests
I want to test a complex formula
I want to test a formula with a big value
I want to test a formula with many precedents
Add new tests
SUM
=IF(SUM(D4:D8)<>100%,"ERROR","100%")
Name of Program: Asset Management of Federally-Owned Real Property
Section I: Program Purpose & Design (Yes,No)
Questions
Ans.
Weighting
Weighted Score
1 Is the program purpose clear? Yes 20% 0.2
2 Does the program address a specific interest, problem or need? Yes 20% 0.2
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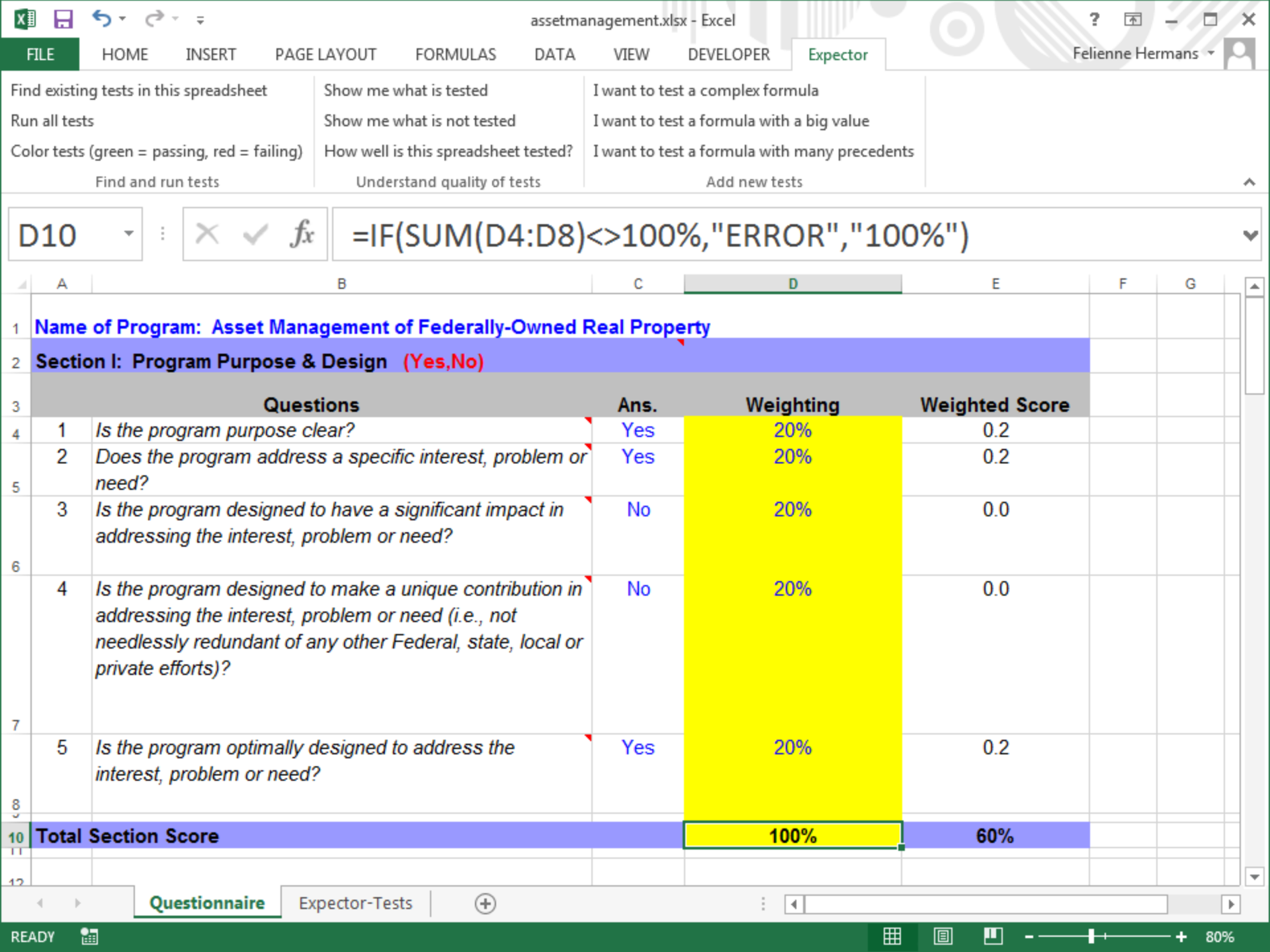
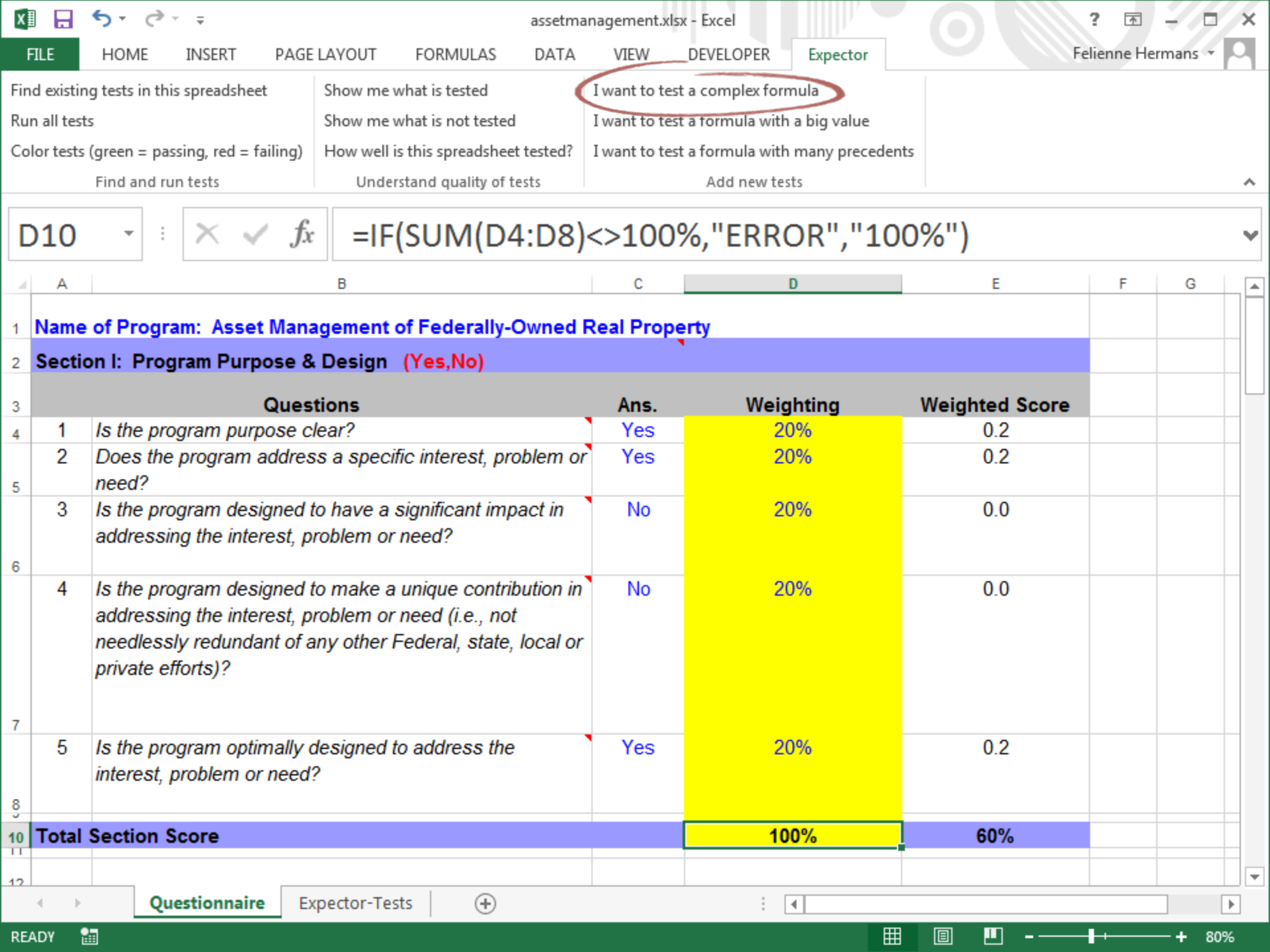
4 Is the program designed to make a unique contribution in addressing the interest, problem or need (i.e., not needlessly redundant of any other Federal, state, local or private efforts)? No 20% 0.0
5 Is the program optimally designed to address the interest, problem or need? Yes 20% 0.2
Total Section Score
=IF(SUM(D4:D8)<>100%
60%
Questionnaire
Expector-Tests
EDIT
80%



Name of Program: Asset Management of Federally-Owned Real Property

Section I: Program Purpose & Design (Yes,No)

	Questions	Ans.	Weighting	Weighted Score
1	*Is the program purpose clear?*	Yes	20%	0.2
2	*Does the program address a specific interest, problem or need?*	Yes	20%	0.2
3	*Is the program designed to have a significant impact in addressing the interest, problem or need?*	No	20%	0.0
4	*Is the program designed to make a unique contribution in addressing the interest, problem or need (i.e., not needlessly redundant of any other Federal, state, local or private efforts)?*	No	20%	0.0
5	*Is the program optimally designed to address the interest, problem or need?*	Yes	20%	0.2
Total Section Score			**100%**	**60%**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Section I: Program Purpose & Design (Yes,No)
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Ans.
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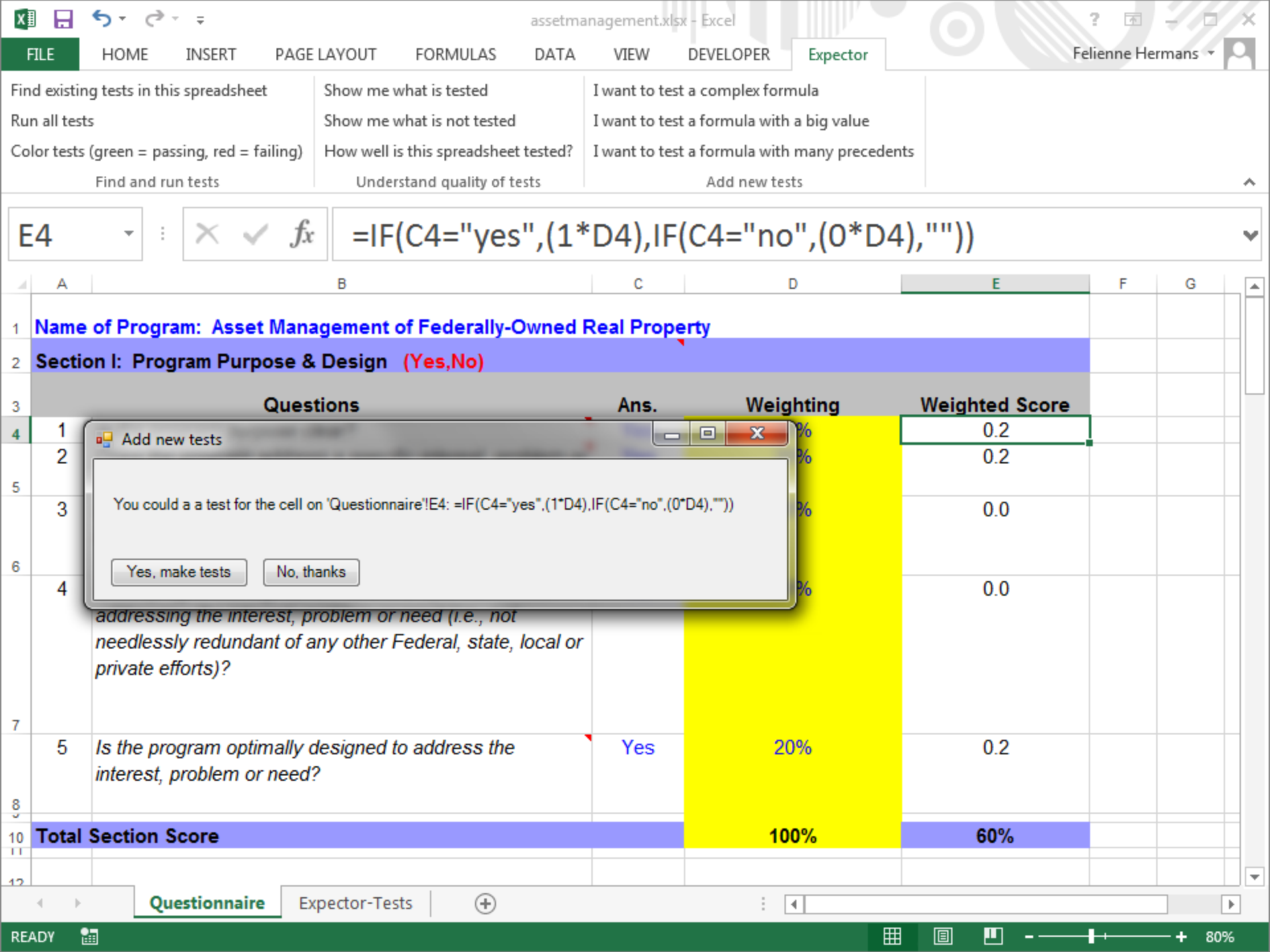
4 Is the program designed to make a unique contribution in addressing the interest, problem or need (i.e., not needlessly redundant of any other Federal, state, local or private efforts)? No 20% 0.0
5 Is the program optimally designed to address the interest, problem or need? Yes 20% 0.2
Total Section Score 100% 60%
Questionnaire
Expector-Tests
READY
80%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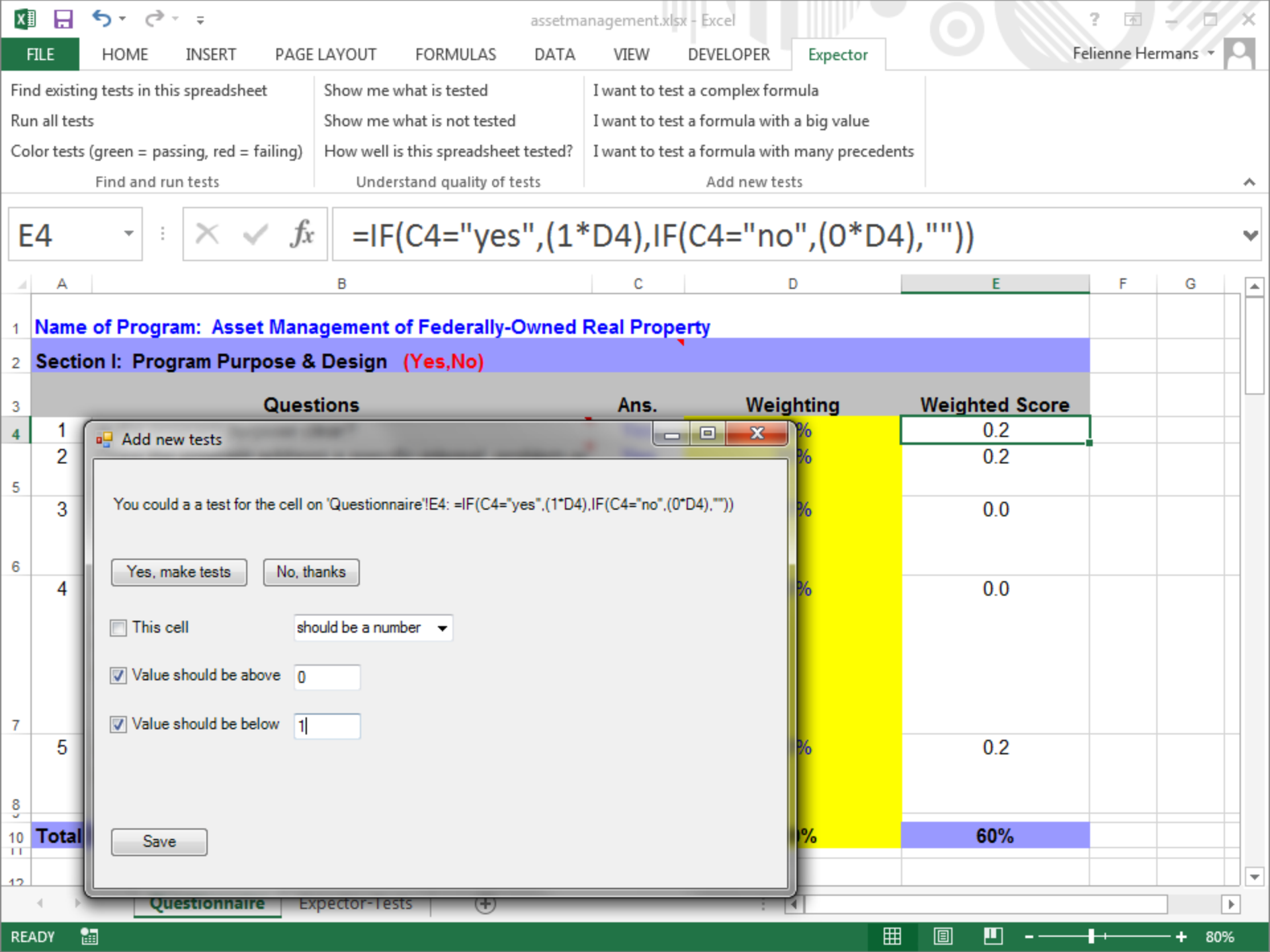
Show me what is not tested
How well is this spreadsheet tested?
Understand quality of tests
I want to test a complex formula
I want to test a formula with a big value
I want to test a formula with many precedents
Add new tests
E4
=IF(C4="yes",(1*D4),IF(C4="no",(0*D4),""))
Name of Program: Asset Management of Federally-Owned Real Property
Section I: Program Purpose & Design (Yes,No)
Questions
Ans.
Weighting
Weighted Score
1
0.2
2
0.2
3
0.0
4
addressing the interest, problem or need (i.e., not needlessly redundant of any other Federal, state, local or private efforts)?
0.0
5
Is the program optimally designed to address the interest, problem or need?
Yes
20%
0.2
Total Section Score
100%
60%
Add new tests
You could a a test for the cell on 'Questionnaire'!E4: =IF(C4="yes",(1*D4),IF(C4="no",(0*D4),""))
Yes, make tests
No, thanks
Questionnaire
Expector-Tests
READY
80%


assetmanagement.xlsx - Excel
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Add new tests
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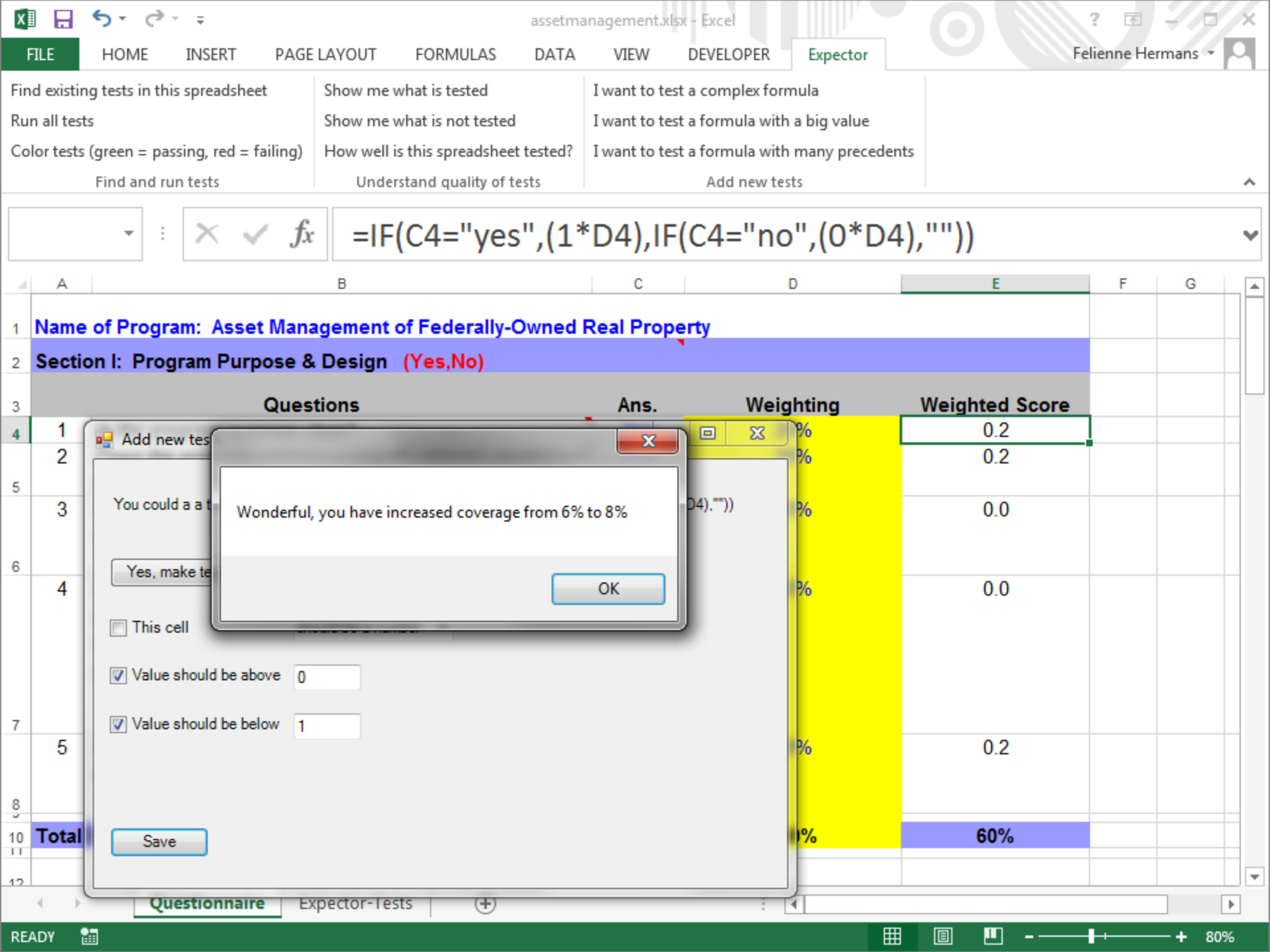
Name of Program: Asset Management of Federally-Owned Real Property
Section I: Program Purpose & Design (Yes,No)
Questions
Ans.
Weighting
Weighted Score
1
0.2
2
0.2
3
0.0
4
0.0
5
0.2
Total
60%
Add new tests
You could a a test for the cell on 'Questionnaire'!E4: =IF(C4="yes",(1*D4),IF(C4="no",(0*D4),""))
Yes, make tests
No, thanks
This cell
should be a number
Value should be above
0
Value should be below
1
Save
Questionnaire
Expector-Tests
READY
80%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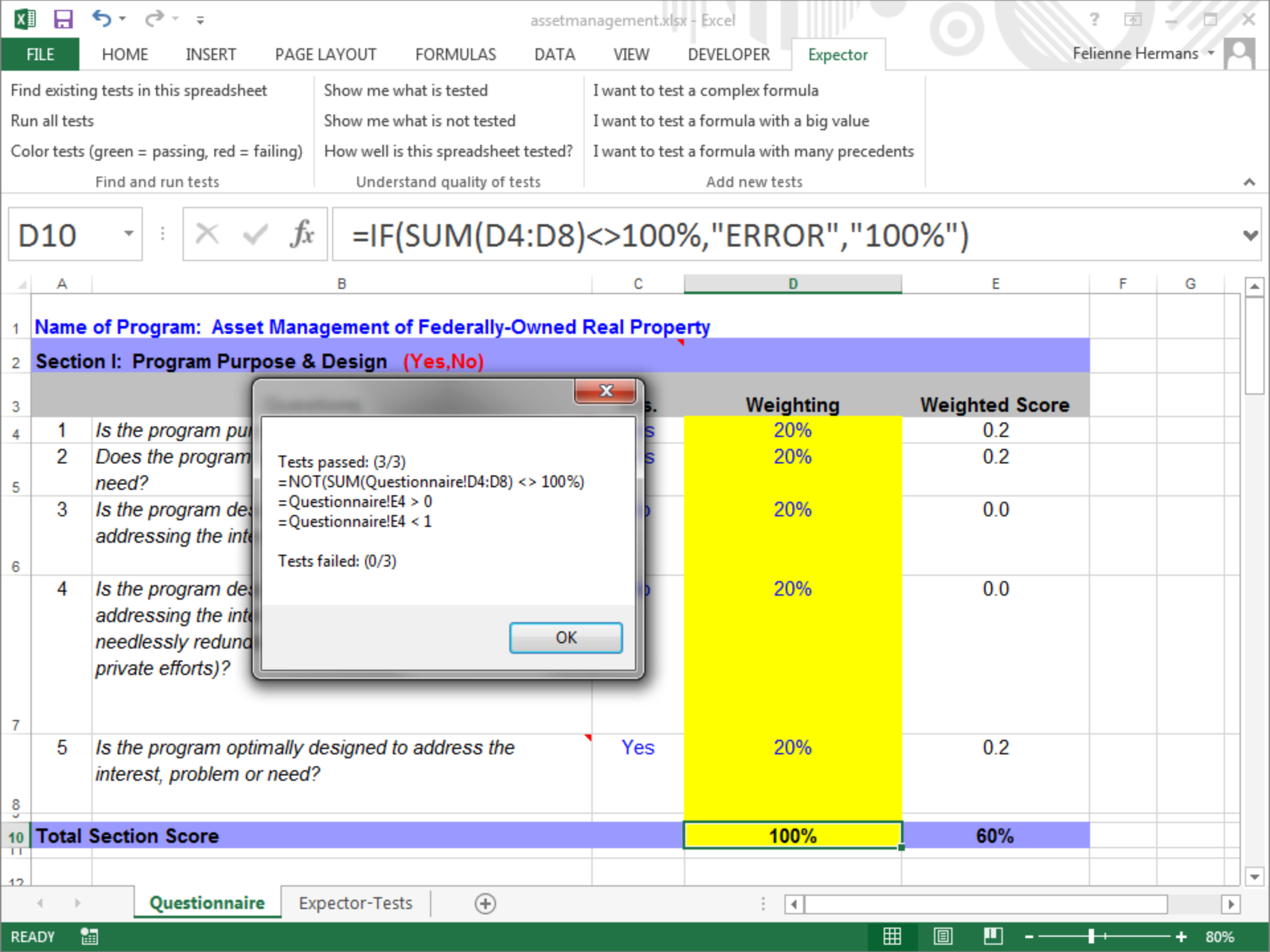
Add new tests
=IF(C4="yes",(1*D4),IF(C4="no",(0*D4),""))
Name of Program: Asset Management of Federally-Owned Real Property
Section I: Program Purpose & Design (Yes,No)
Questions
Ans.
Weighting
Weighted Score
1
0.2
2
0.2
3
0.0
4
0.0
5
0.2
Total
60%
Add new tes
You could a a t
Yes, make te
This cell
Value should be above
0
Value should be below
1
Save
Wonderful, you have increased coverage from 6% to 8%
OK
Questionnaire
Expector-Tests
READY
80%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I want to test a formula with a big value
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Add new tests
D10
=IF(SUM(D4:D8)<>100%,"ERROR","100%")
Name of Program: Asset Management of Federally-Owned Real Property
Section I: Program Purpose & Design (Yes,No)
Weighting
Weighted Score
1
Is the program pur
20%
0.2
2
Does the program
need?
20%
0.2
3
Is the program des
addressing the inte
20%
0.0
4
Is the program des
addressing the inte
needlessly reduno
private efforts)?
20%
0.0
5
Is the program optimally designed to address the interest, problem or need?
Yes
20%
0.2
Total Section Score
100%
60%
Tests passed: (3/3)
=NOT(SUM(Questionnaire!D4:D8) <> 100%)
=Questionnaire!E4 > 0
=Questionnaire!E4 < 1
Tests failed: (0/3)
OK
Questionnaire
Expector-Tests
READY
80%


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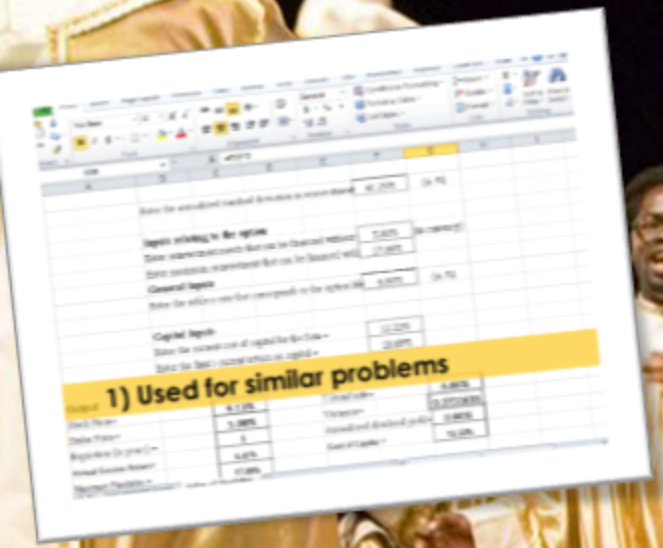
Spreadsheets are code



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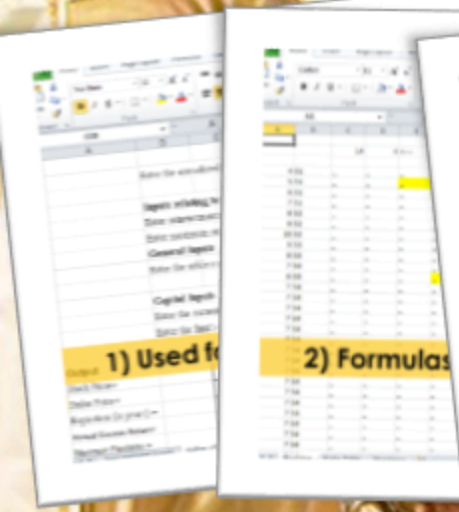

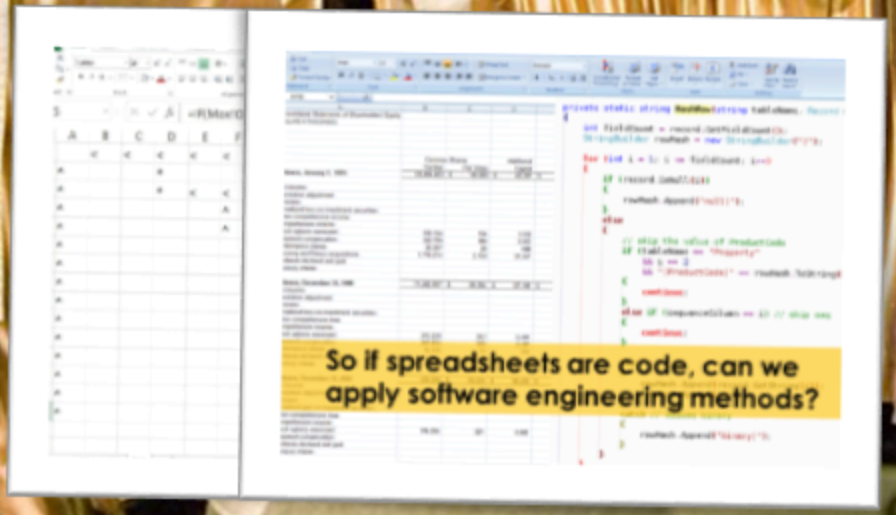

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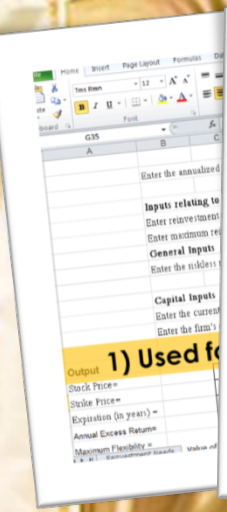

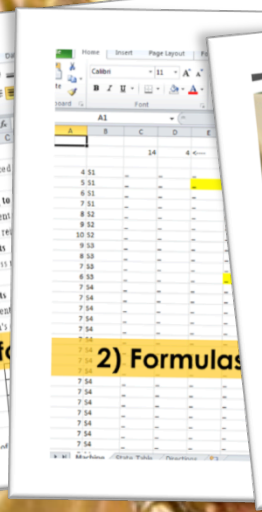

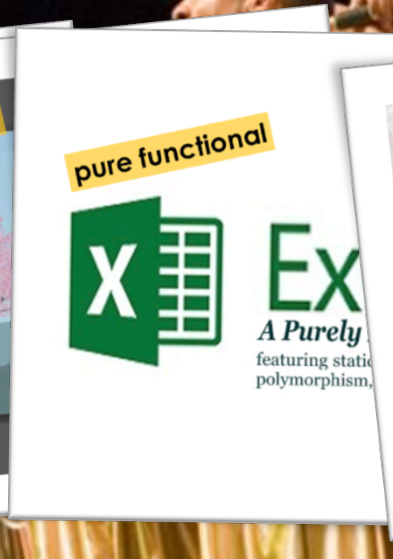

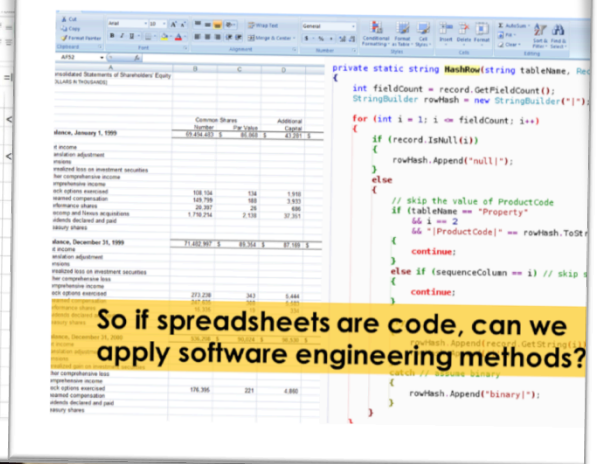

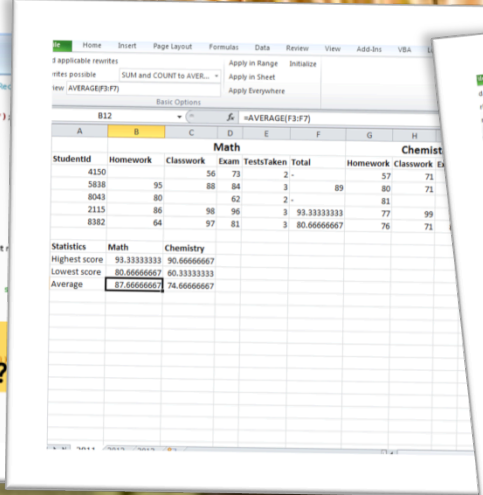

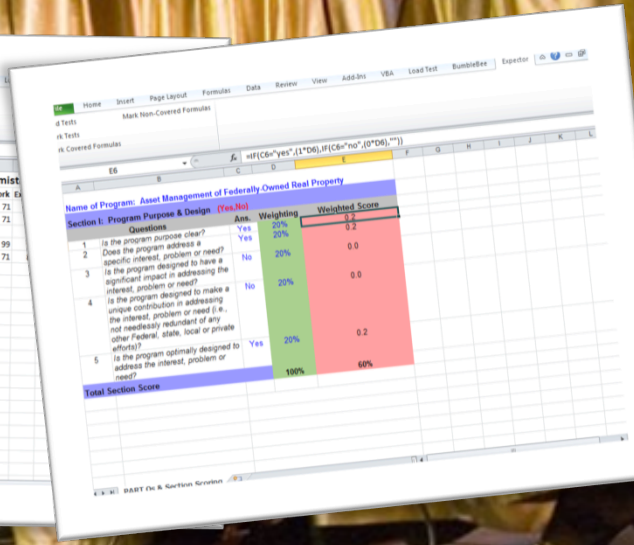

Spreadsheets are code