Lab 01: Data Analysis I
Uncertainty in Calculations with Measured Quantities

Objective

To estimate the uncertainty in result of calculation with measured quantities.

Introduction

When you measure something, there is always an uncertainty in the measurement. For example, if you want to measure the length of the rectangle shown in the figure below, you probably estimate that the length l should be between 5.23 to 5.25 cm. You can express this by writing $l = 5.24 \pm 0.01\ cm$. We call 5.24 the most probable value and we use symbol l_0 for it. We call 0.01 the uncertainty or the error in the measurement and we use symbol Δl for it. So, we can write our measurement in a symbolic form as $l = l_0 \pm \Delta l$. The relative error in the measurement of the length is $\Delta l/l_0 = 0.01/5.24 = 0.002$. The percent error in the measurement of the length is $(\Delta l/l_0) \times 100\% = 0.2\%$.

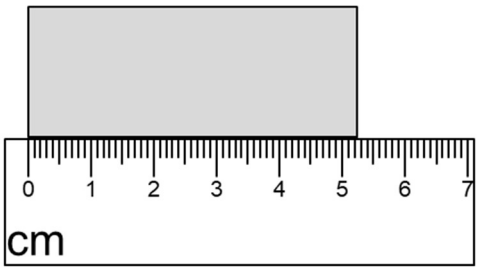


Fig. 1. Measuring a length of a rectangle

Since the error in a measurement is an estimation, we need only to use one or at most two significant digits to express it. Similarly, when you report the relative error or percent error of a measurement, you should use one or two significant digits. But if the error or relative error involves intermediate calculation steps, we may keep two or three significant digits for the purpose of the calculation. When reporting a measurement, the most probable value and the error should have the same precision. The table below shows some examples.

Table 1. Examples on how to report measurements and their errors.

Mistake	Correction	Reason
5.24264 ± 0.01325	5.24 ± 0.01	The error should have one or two significant digits.
5.2426 ± 0.01	5.24 ± 0.01	The most probable value and the error should have the same precision.
5.24 ± 0.0136	5.24 ± 0.01	The most probable value and the error should have the same precision
Relative error: $0.01/5.24 = 0.00191$	Relative error: $0.01/5.24 = 0.002$	Relative error should have one or two significant digits.
Percent error: $(0.01/5.24) \times 100\% = 0.191\%$	Percent error: $(0.01/5.24) \times 100\% = 0.2\%$	Percent error should have one or two significant digits.

Exercise 1:
Suppose you measure the width w of the rectangle and you estimate it between 2.05 and 2.07 cm. Fill the following table using $w = w_0 \pm \Delta w$.

	Symbol	Value and units
The most probable value	w_0	
The error		
The relative error		
The percent error		

In the following, we will estimate the resultant error when the measurements of the length l and width w are combined in an arithmetic operation such as addition or multiplication. We will use the function $f(l,w)$ to represent this operation. The resultant error Δf can be estimated from the minimum and maximum possible deviations of f as follows.

$$\Delta f = \frac{f_{max} - f_{min}}{2} \quad (1)$$

Addition and subtraction of measurements

Rule 1: The resultant error in adding or subtracting two measurements is the sum of the errors of the individual measurement.

$f = l + w \quad \rightarrow \quad \Delta f = \Delta l + \Delta w$
$f = l - w \quad \rightarrow \quad \Delta f = \Delta l + \Delta w$

Example 1:
Let $l = 30.2 \pm 0.2$ and $w = 10.3 \pm 0.1$, find $l + w$ and $l - w$.

Answer 1:
$l + w = (30.2 + 10.3) \pm (0.2 + 0.1) = 40.5 \pm 0.3$
$l - w = (30.2 - 10.3) \pm (0.2 + 0.1) = 19.9 \pm 0.3$

Exercise 2:
Let $l = 70.5 \pm 0.3$ and $w = 15.1 \pm 0.2$, find $l + w$ and $l - w$.

Justification for Rule 1:
For addition $f = l + w$,
The maximum possible value of f is $f_{max} = l_0 + \Delta l + w_0 + \Delta w$
The minimum possible value of f is $f_{min} = l_0 - \Delta l + w_0 - \Delta w$

$$\Delta f = \frac{f_{max} - f_{min}}{2} = \Delta l + \Delta w$$

For subtraction $f = l - w$,
The maximum possible value of f is $f_{max} = l_0 + \Delta l - (w_0 - \Delta w)$
The minimum possible value of f is $f_{min} = l_0 - \Delta l - (w_0 + \Delta w)$

$$\Delta f = \frac{f_{max} - f_{min}}{2} = \Delta l + \Delta w$$

Multiplication of a measurement with a constant

Rule 2: The resultant error when a measurement l is multiplied by a constant c is the product of the constant and the error of the measurement.

$$f = c\,l \qquad \rightarrow \qquad \Delta f = |c|\Delta l$$

Example 2:

Let $l = 41.3 \pm 0.3$ and $c = 2.351$, find cl.

Answer 2:

$cl_0 = 97.096$

$c\Delta l = 0.705$

$cl = 97.1 \pm 0.7$

You need to keep one or two significant digits in the error, and you need to make the precision of the most probable value and the error the same.

Exercise 3:

Let $l = 70.5 \pm 0.4$ and $c = \pi$, find cl.

Justification for Rule 2:

For $c > 0$,

The maximum possible value of f is $f_{max} = c(l_0 + \Delta l)$

The minimum possible value of f is $f_{min} = c(l_0 - \Delta l)$

$$\Delta f = \frac{f_{max} - f_{min}}{2} = c\Delta l$$

For $c < 0$,

The maximum possible value of f is $f_{max} = c(l_0 - \Delta l)$

The minimum possible value of f is $f_{min} = c(l_0 + \Delta l)$

$$\Delta f = \frac{f_{max} - f_{min}}{2} = -c\Delta l$$

Multiplication and division of measurements

Rule 3: The resultant relative error when two measurements are multiplied or divided is the sum of the relative errors of the individual measurement.

$$f = lw \qquad \rightarrow \qquad \frac{\Delta f}{f_0} = \frac{\Delta l}{l_0} + \frac{\Delta w}{w_0}$$

$$f = l/w \qquad \rightarrow \qquad \frac{\Delta f}{f_0} = \frac{\Delta l}{l_0} + \frac{\Delta w}{w_0}$$

Example 3:

Let $l = 30.2 \pm 0.2$ and $w = 10.3 \pm 0.1$, find $l\,w$ and l/w.

Answer 3:

$l_0 w_0 = 30.2 \times 10.3 = 311.06$

$\frac{\Delta(lw)}{l_0 w_0} = \frac{\Delta l}{l_0} + \frac{\Delta w}{w_0} = \frac{0.2}{30.2} + \frac{0.1}{10.3} = 0.0163$

$\rightarrow \Delta(lw) = 0.0163 \times l_0 w_0 = 0.0163 \times 311.06 = 5.08$

$lw = 311 \pm 5$

$l_0/w_0 = 30.2/10.3 = 2.932$

$\frac{\Delta(l/w)}{l_0/w_0} = \frac{\Delta l}{l_0} + \frac{\Delta w}{w_0} = \frac{0.2}{30.2} + \frac{0.1}{10.3} = 0.0163$

$\rightarrow \Delta(l/w) = 0.0163 \times (l_0/w_0) = 0.0163 \times 2.932 = 0.04788$

$l/w = 2.93 \pm 0.05$

Note that we use three significant digits to express the relative error, since it is used later in calculating the error.

Exercise 4:

Let $l = 3.52 \pm 0.04$ and $w = 2.65 \pm 0.05$, find $l\,w$ and l/w.

Justification for Rule 3:

For multiplication $f = lw$,

The maximum possible value of f is $f_{max} = (l_0 + \Delta l)(w_0 + \Delta w) = l_0 w_0 + w_0 \Delta l + l_0 \Delta w + \Delta l \Delta w$

The minimum possible value of f is $f_{min} = (l_0 - \Delta l)(w_0 - \Delta w) = l_0 w_0 - w_0 \Delta l - l_0 \Delta w + \Delta l \Delta w$

$$\Delta f = \frac{f_{max} - f_{min}}{2} = w_0 \Delta l + l_0 \Delta w$$

$$\rightarrow \frac{\Delta f}{f_0} = \frac{w_0 \Delta l}{l_0 w_0} + \frac{l_0 \Delta w}{l_0 w_0} = \frac{\Delta l}{l_0} + \frac{\Delta w}{w_0}$$

For division $f = \frac{l}{w}$,

The maximum possible value of f is $f_{max} = \frac{l_0 + \Delta l}{w_0 - \Delta w}$

The minimum possible value of f is $f_{min} = \frac{l_0 - \Delta l}{w_0 + \Delta w}$

$$\Delta f = \frac{f_{max} - f_{min}}{2} = \frac{1}{2}\left(\frac{l_0 + \Delta l}{w_0 - \Delta w} - \frac{l_0 - \Delta l}{w_0 + \Delta w}\right) = \frac{w_0 \Delta l + l_0 \Delta w}{w_0^2 - \Delta w^2}$$

We can ignore Δw^2 in the denominator since it is much smaller than $w_0^2 \rightarrow \Delta f \approx \frac{1}{w_0}\Delta l + \frac{l_0}{w_0^2}\Delta w$

$$\rightarrow \frac{\Delta f}{f_0} = \frac{\Delta l}{w_0 (l_0/w_0)} + \frac{l_0 \Delta w}{w_0^2 (l_0/w_0)} = \frac{\Delta l}{l_0} + \frac{\Delta w}{w_0}$$

Raising a measurement to a power of constant value

Rule 4: The resultant relative error of raising a measurement to a power of constant value c is the absolute value of the constant multiplied by the relative errors of the measurement.

$$f = l^c \qquad \rightarrow \qquad \frac{\Delta f}{f_0} = |c| \frac{\Delta l}{l_0}$$

Example 4:

Let $l = 51.3 \pm 0.8$ and $c = -0.5$, find l^c.

Answer 4:

$l_0^c = 51.3^{-0.5} = 0.1396$

$\frac{\Delta(l^c)}{l_0^c} = |c| \frac{\Delta l}{l_0} = 0.00780$

$\Delta(l^c) = l_0^c \times |c| \frac{\Delta l}{l_0} = 0.00109$

$l^c = 0.140 \pm 0.001$

Exercise 5:

Let $l = 51.3 \pm 0.8$ and $c = 0.5$, find l^c.

Justification for Rule 4:

For $c > 0$,

The maximum possible value of f is $f_{max} = (l_0 + \Delta l)^c = l_0^c \left(1 + \frac{\Delta l}{l_0}\right)^c \approx l_0^c (1 + c\frac{\Delta l}{l_0})$

The minimum possible value of f is $f_{min} = (l_0 - \Delta l)^c = l_0^c \left(1 - \frac{\Delta l}{l_0}\right)^c \approx l_0^c (1 - c\frac{\Delta l}{l_0})$

$$\Delta f = \frac{f_{max} - f_{min}}{2} = l_0^c c \frac{\Delta l}{l_0}$$

$$\rightarrow \frac{\Delta f}{f_0} = \frac{l_0^c c \frac{\Delta l}{l_0}}{l_0^c} = c \frac{\Delta l}{l_0}$$

For $c < 0$,

The maximum possible value of f is $f_{max} = (l_0 - \Delta l)^c = l_0^c \left(1 - \frac{\Delta l}{l_0}\right)^c \approx l_0^c (1 - c\frac{\Delta l}{l_0})$

The minimum possible value of f is $f_{min} = (l_0 + \Delta l)^c = l_0^c \left(1 + \frac{\Delta l}{l_0}\right)^c \approx l_0^c (1 + c\frac{\Delta l}{l_0})$

$$\Delta f = \frac{f_{max} - f_{min}}{2} = -l_0^c c \frac{\Delta l}{l_0}$$

$$\rightarrow \frac{\Delta f}{f_0} = \frac{-l_0^c c \frac{\Delta l}{l_0}}{l_0^c} = -c\frac{\Delta l}{l_0}$$

Exercise 6:

In this exercise you will check, that if $\Delta l \ll l_0$, then $\left(1 + \frac{\Delta l}{l_0}\right)^c \approx 1 + c\frac{\Delta l}{l_0}$ and $\left(1 - \frac{\Delta l}{l_0}\right)^c \approx 1 - c\frac{\Delta l}{l_0}$.
Let $l_0 = 50$ and $\Delta l = 1$.

c	0.5	2	3	-3	-2	-0.5
$\left(1 + \frac{\Delta l}{l_0}\right)^c$						
$1 + c\frac{\Delta l}{l_0}$						
Is $\left(1 + \frac{\Delta l}{l_0}\right)^c \approx 1 + c\frac{\Delta l}{l_0}$?						
$\left(1 - \frac{\Delta l}{l_0}\right)^c$						
$1 - c\frac{\Delta l}{l_0}$						
Is $\left(1 - \frac{\Delta l}{l_0}\right)^c \approx 1 - c\frac{\Delta l}{l_0}$?						

Average of repeated measurements

Rule 5: The resultant error in the average of measurements of the same quantity repeated N times is the error of one measurement divided by the square root of the number of measurements.

$$f = \frac{l_1 + l_2 + \cdots + l_N}{N} \quad \rightarrow \quad \Delta f = \frac{\Delta l}{\sqrt{N}}$$

Example 5:

The following are 9 repeated measurements for l.
91.38, 89.57, 89.57, 89.17, 88.19, 90.52, 88.87, 90.82, 89.84
Find the average of these measurements and estimate the error in the average value.

Answer 5:

You can use Excel function AVERAGE() to find the average value and Excel function STDEV.S() to find the standard deviation.

$$\text{Average value} = \bar{l}_0 = \frac{91.38 + 89.57 + 89.57 + 89.17 + 88.19 \quad 90.52 + 88.87 + 90.82 + 89.84}{9} = 89.77$$

$$\Delta l = \sqrt{\sum_{i=1}^{N} \frac{(l_i - \bar{l})^2}{N-1}} = \sqrt{\frac{(91.38 - 89.77)^2 + (89.57 - 89.77)^2 + \cdots + (89.84 - 89.77)^2}{9-1}} = 0.945$$

$$\Delta \bar{l} = \frac{\Delta l}{\sqrt{N}} = \frac{0.945}{\sqrt{9}} = 0.315$$

$$\bar{l} = \bar{l}_0 \pm \Delta \bar{l} = 89.8 \pm 0.3$$

Exercise 7:

The following are 16 repeated measurements for l.

55.08
55.84
58.63
53.16
59.84
56.55
54.35
54.69
53.95
55.38
52.57
54.39
53.83
56.31
52.84
55.34

Find the average of these measurements and estimate the error in the average value.

Justification for Rule 5:

There are two types of errors in a measurement: systematic error and random error. The systematic error is a fix and repeatable shift in the measurement caused, for example, by an incorrectly calibrated instrument. The random error varies unpredictably from one measurement to another due to uncontrollable variations in the experiment. For example, the effect of the room temperature on the length of a ruler.

In this lab, we assume that measurements have no systematic errors, and only have random errors. Random errors often have a normal probability distribution, as shown in Fig. 2. The most probable value l_0 is the mean of the distribution and the error Δl is usually taken as the standard deviation of the distribution. There is a chance of 68% for a measurement to be between $l_0 - \Delta l$ and $l_0 + \Delta l$.

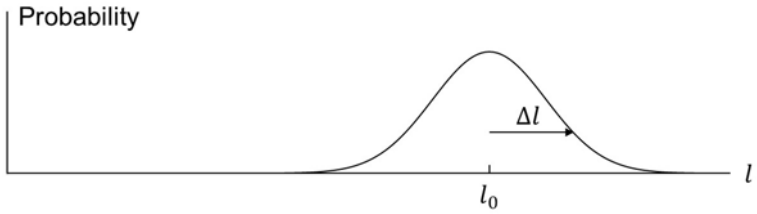


Fig. 2. Probability distribution for a random value with a normal distribution.

For adding or subtracting two independent measurements, Rule 1 gives the worst-case scenario. Statistically, it can be shown that a better and smaller estimate of the error is given by

$$\Delta f = \sqrt{\Delta l^2 + \Delta w^2}$$

Thus, for summing N independent measurements of l, a better estimate of the error is

$$\Delta(l_1 + l_2 + \cdots + l_N) = \sqrt{\Delta l_1^2 + \Delta l_2^2 + \cdots \Delta l_N^2} = \sqrt{N \Delta l^2} = \sqrt{N}\Delta l$$

Hence, the error in the average of these measurements is

$$\Delta f = \frac{\Delta(l_1 + l_2 + \cdots + l_N)}{N} = \frac{\sqrt{N}\Delta l}{N} = \frac{\Delta l}{\sqrt{N}}$$

Also, for multiplying or dividing two independent measurements, Rule 3 gives the worst-case scenario. From statistics, a better and smaller estimate of relative error is

$$\frac{\Delta f}{f} = \sqrt{\left(\frac{\Delta l}{l_0}\right)^2 + \left(\frac{\Delta w}{w_0}\right)^2}$$

Rule 2 for multiplying a measurement by a constant and Rule 4 for raising a measurement by a constant hold always since no more than one independent measurement is involved.

In this lab, we will use the worst-case scenario estimate for the error.

Exercise 8:

In this exercise, we will use Excel to check Rule 5. We will use Excel function NORM.INV(RAND(), mean, standard_dev), which generates a random number with normal distribution. It simulates the process of measurement with a random error. We will generate 30 sets each of which has 25 measurements. For each set, we find its average and its standard deviation. Then we find the average and the standard deviation of the 30 averages. The standard deviation of each set is the error in individual measurement Δl and the standard deviation of the 30 averages is the error in the average value $\Delta \bar{l}$. You will check that $\Delta \bar{l} \approx \Delta l/\sqrt{25}$.

L0	55.0													
DeltaL	2.0													
number of measurements per set	25													
expected error in the average of a set	0.4													
			set 1	set 2	set 3	set 4	set 5	set 6	set 7	set 8	set 9	set 10	set 11	set 12	set 13	set 14
		measurement 1	52.54	57.10	56.17	57.00	59.13	55.28	53.43	53.41	56.18	54.68	53.19	56.54	56.09	58.57
		measurement 2	55.58	56.53	50.97	56.04	54.56	54.59	55.76	54.31	53.78	55.90	52.53	51.51	55.58	58.50
		measurement 3	53.53	58.14	57.09	54.58	57.53	54.84	54.59	56.50	54.63	54.37	51.78	51.03	53.92	54.36
		measurement 4	53.38	50.66	55.38	56.87	55.19	54.80	53.96	58.17	54.60	52.78	56.92	56.03	56.51	52.15
		measurement 5	55.67	54.98	53.16	55.10	54.13	55.86	55.46	54.67	55.84	50.77	55.79	55.83	54.06	53.61
		measurement 6	52.02	54.73	55.88	55.70	55.50	52.60	52.11	54.62	54.26	59.71	57.11	55.24	55.70	53.84
		measurement 7	56.56	52.96	55.75	55.29	56.55	53.88	57.24	57.08	54.12	52.58	53.75	54.71	57.12	56.70
		measurement 8	56.92	54.13	52.33	53.27	53.55	55.88	53.12	59.28	53.37	55.82	54.37	59.96	55.38	52.68
		measurement 9	50.27	57.27	54.20	56.73	56.38	56.40	51.56	52.11	53.15	56.28	53.18	54.62	51.71	56.79
		measurement 10	55.89	56.22	58.21	55.54	57.26	56.25	55.52	59.61	54.76	54.03	53.60	58.83	55.62	56.09
		measurement 11	58.93	51.94	57.26	52.47	53.77	52.54	55.20	55.91	56.32	52.46	54.45	53.66	58.13	56.61
		measurement 12	57.55	56.52	53.40	56.74	59.77	54.54	55.78	54.33	58.03	59.18	52.96	51.54	55.10	57.00
		measurement 13	55.84	52.14	52.84	54.94	52.83	57.05	53.53	55.12	51.38	57.13	51.66	58.70	55.10	55.55
		measurement 14	59.02	54.74	58.20	59.48	56.45	50.21	53.85	55.46	55.79	54.84	53.15	55.33	55.81	55.20
		measurement 15	54.19	53.17	56.73	54.26	52.83	53.84	54.28	53.67	57.00	58.42	58.86	53.53	54.17	52.98
		measurement 16	54.27	59.20	55.36	57.70	55.98	55.44	53.54	54.67	54.04	54.65	54.93	57.01	55.57	52.88
		measurement 17	52.28	55.66	58.39	57.60	57.74	56.46	55.17	54.85	53.17	54.42	57.45	53.09	53.68	59.83
		measurement 18	53.07	56.46	55.48	53.55	53.63	54.30	54.69	55.91	53.21	50.47	48.99	56.32	52.74	54.93
		measurement 19	55.94	54.79	50.67	56.43	54.38	51.97	54.12	53.35	53.68	56.69	56.34	57.68	55.89	52.96
		measurement 20	56.05	54.12	56.56	51.78	58.20	52.52	51.90	57.07	58.34	55.51	57.56	54.07	51.70	52.14
		measurement 21	52.92	54.23	52.05	53.19	54.60	55.90	55.45	52.99	55.16	53.92	59.12	53.42	54.04	52.42
		measurement 22	55.02	53.57	56.78	52.62	52.54	56.87	56.62	54.19	52.76	53.46	54.81	50.70	54.55	56.18
		measurement 23	51.42	52.22	55.86	55.42	54.76	54.58	58.60	57.08	53.37	51.94	56.64	56.68	58.83	53.48
		measurement 24	50.72	58.26	53.15	51.95	57.95	55.52	53.77	54.89	52.01	56.39	54.70	59.49	52.38	54.78
		measurement 25	54.57	53.94	54.23	57.36	55.69	48.99	56.17	57.71	51.82	56.00	57.61	57.02	58.71	54.25
		Average of a set	54.57	54.95	55.04	55.26	55.64	54.44	54.62	55.48	54.43	54.90	54.86	55.30	55.12	54.98
		std dev of set	2.4	2.2	2.2	2.0	2.0	2.0	1.7	1.9	1.8	2.4	2.5	2.6	1.9	2.2
Average of set averages	55.1															
Average of set standard deviations	2.1															
standard deviation of set averages	0.35															

You can find step-by-step instructions to do this exercise after Exercise 9.

Exercise 9:

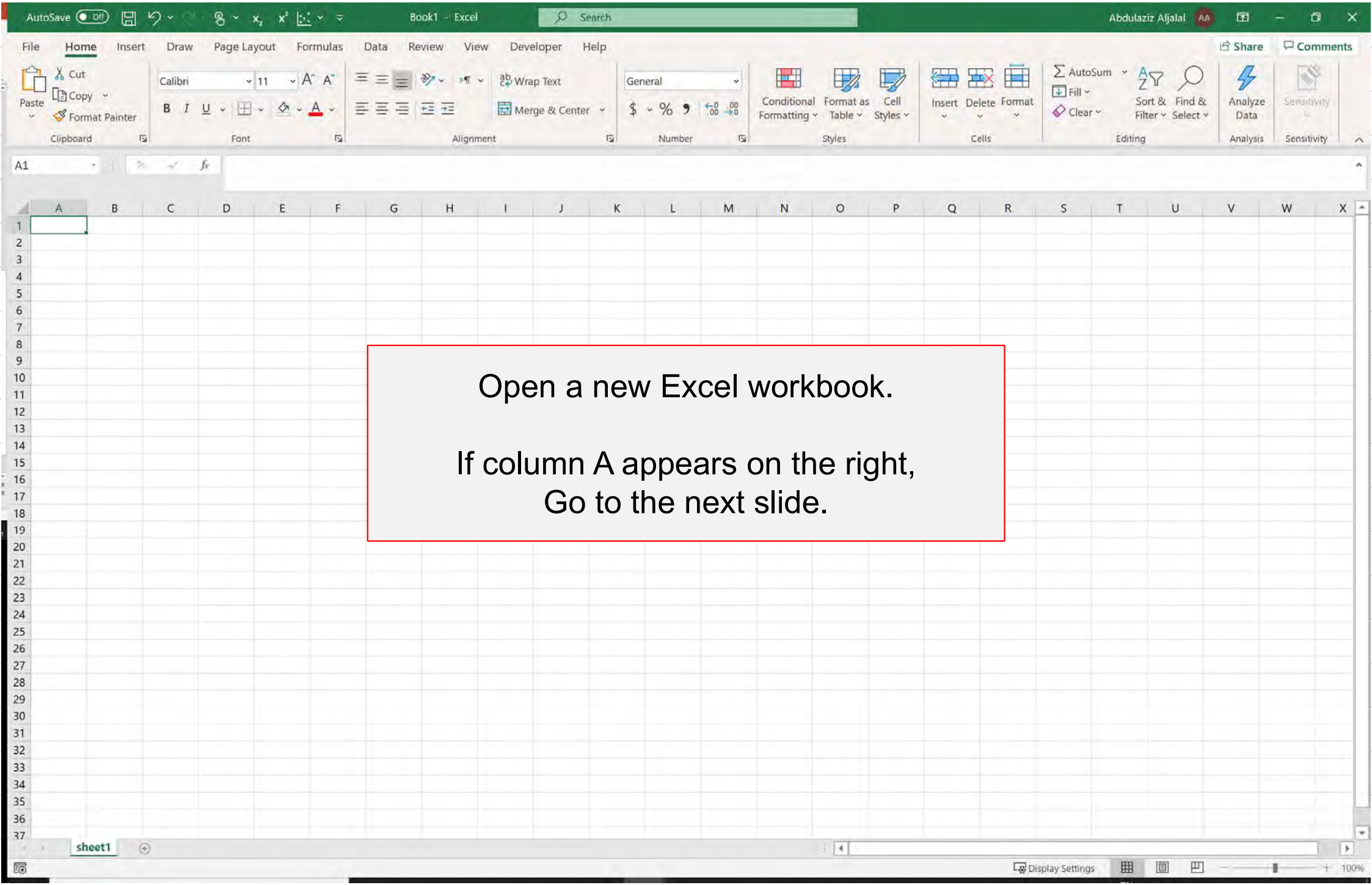
A simple pendulum can be used to measure the gravitational acceleration g. If the oscillation angle is very small, then the period of oscillation T is related to the length of the pendulum according to

$$T = 2\pi\sqrt{\frac{L}{g}}$$

For a pendulum of length $L = 60.0 \pm 0.2\ cm$, 10 different measurements of the period in seconds are found to be

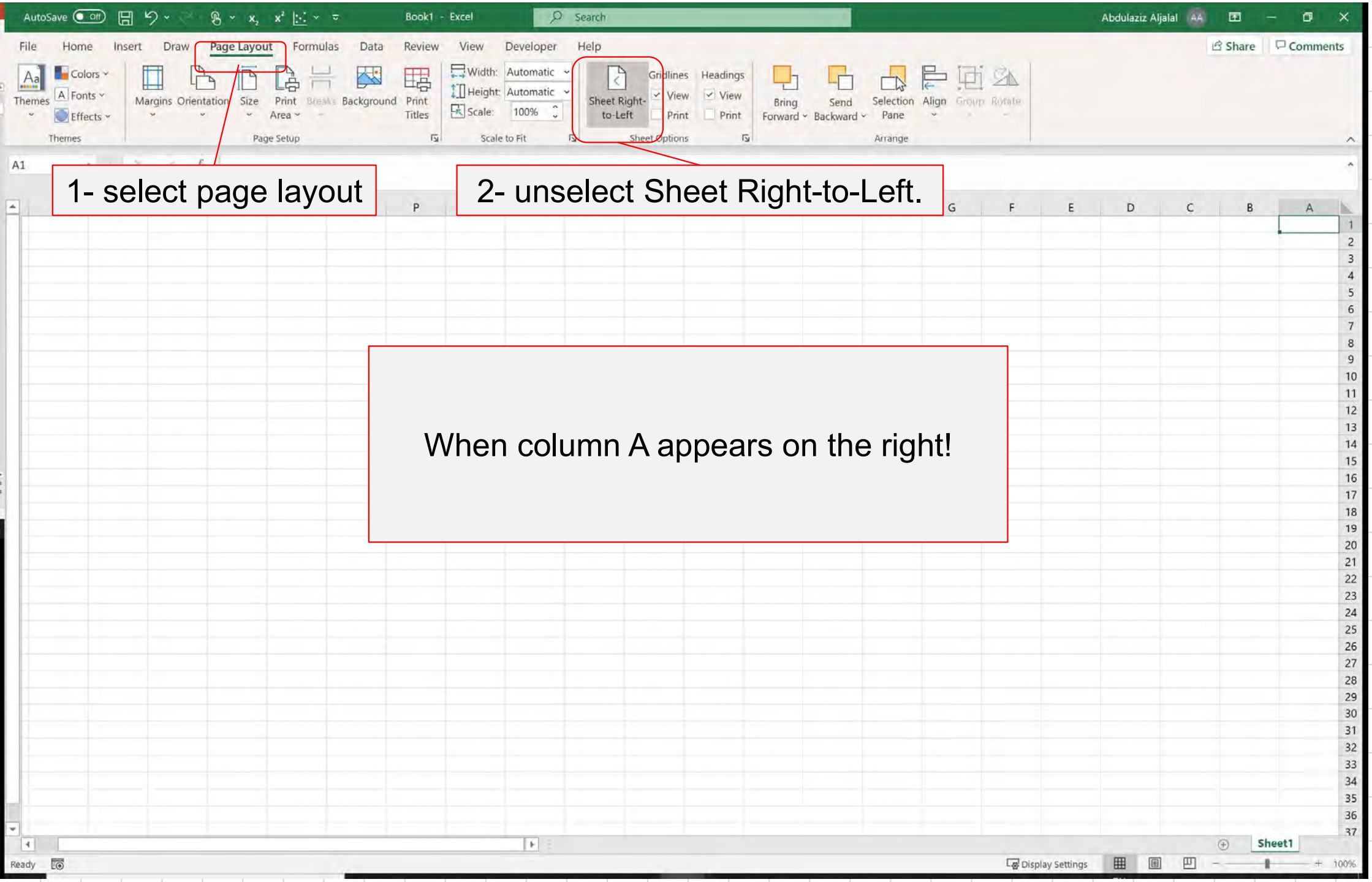
1.58
1.57
1.56
1.57
1.53
1.55
1.55
1.55
1.54
1.60

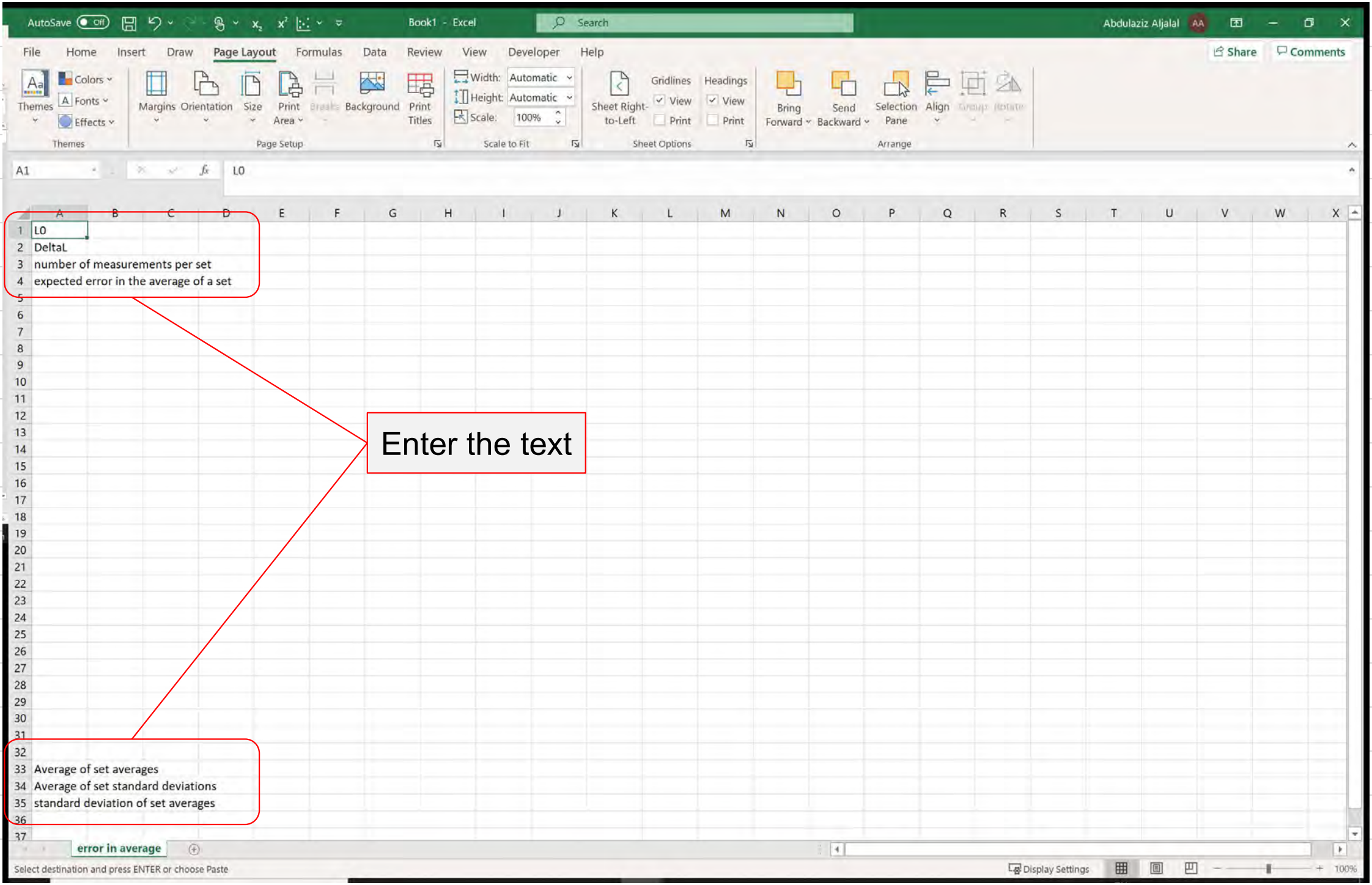
Find the value of gravitational acceleration and estimate its error.

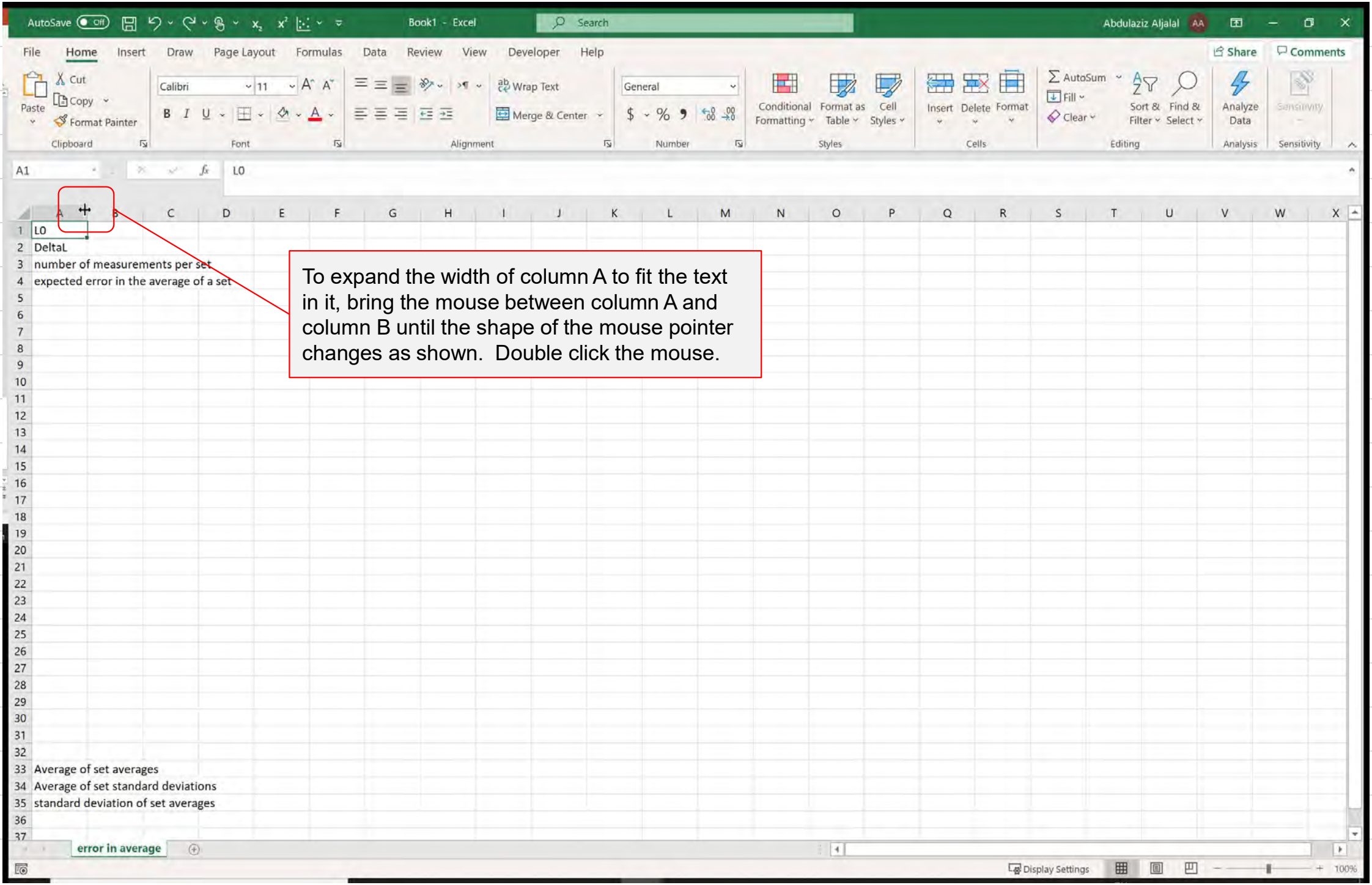


Open a new Excel workbook.

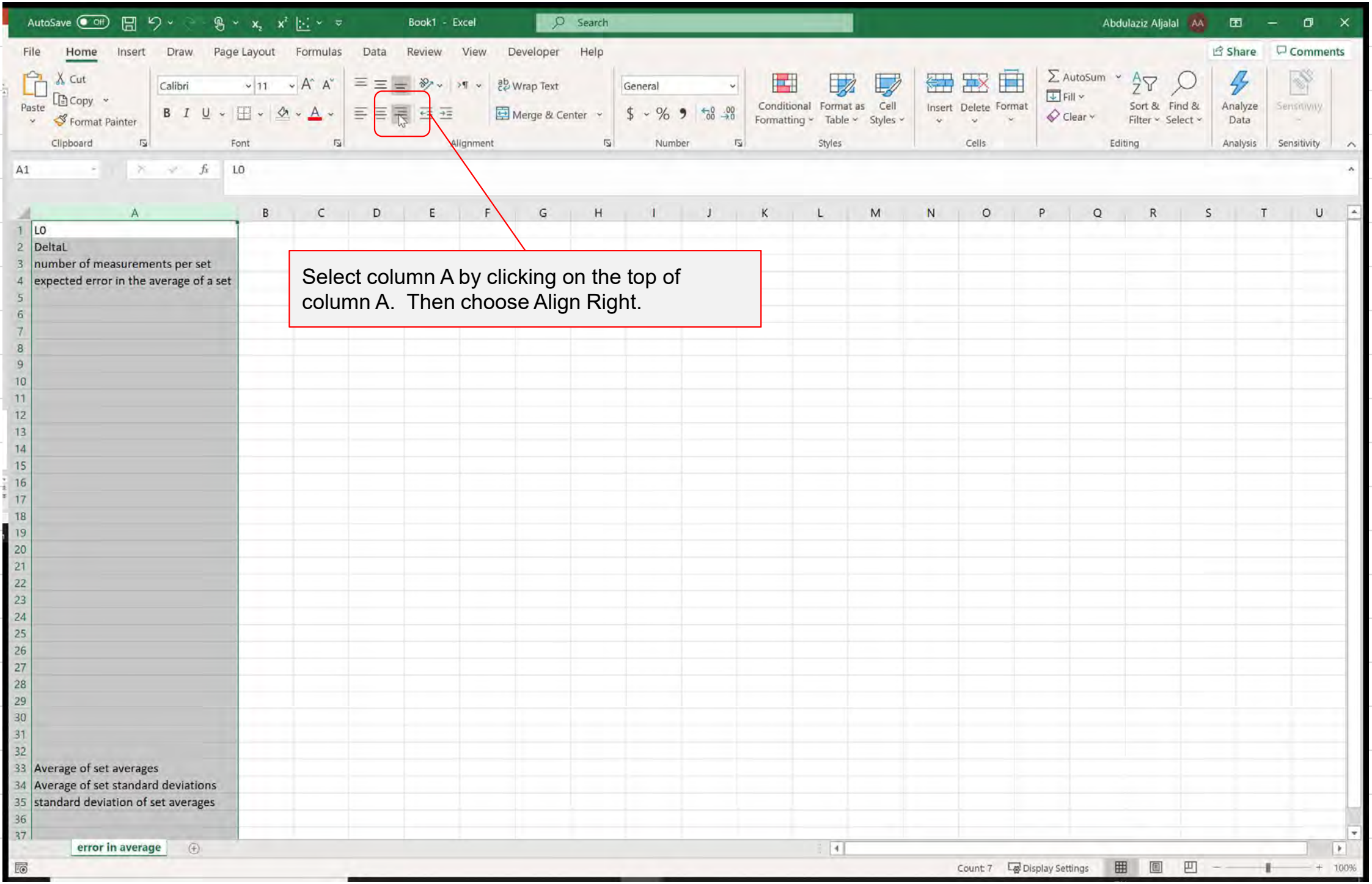
If column A appears on the right,
Go to the next slide.

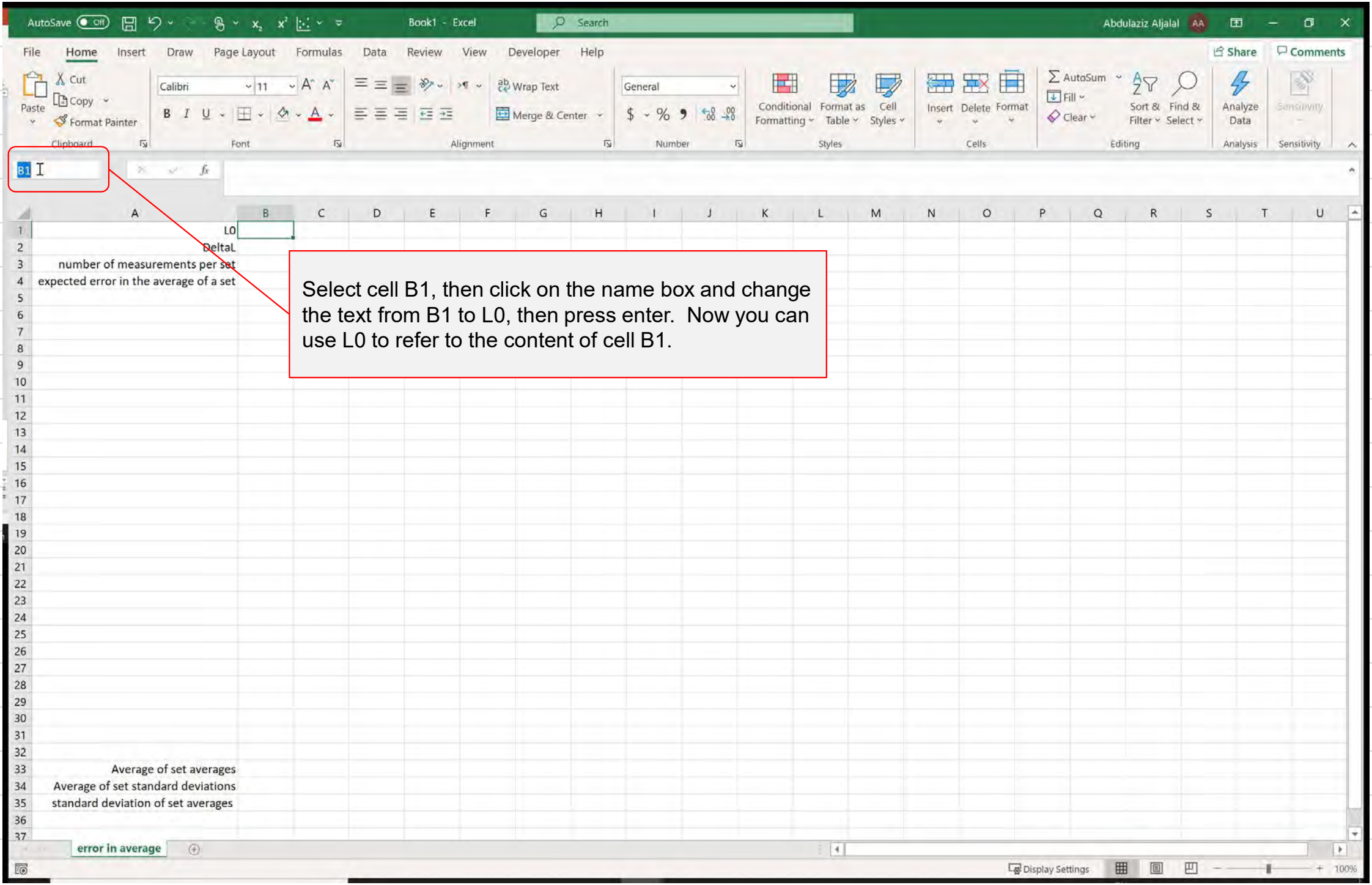

1- select page layout
2- unselect Sheet Right-to-Left.
When column A appears on the right!


Book1 - Excel
Search
Abdulaziz Aljalal
File Home Insert Draw Page Layout Formulas Data Review View Developer Help
Share Comments
Themes Colors Fonts Effects
Margins Orientation Size Print Area Breaks Background Print Titles
Page Setup
Width: Automatic
Height: Automatic
Scale: 100%
Scale to Fit
Sheet Right-to-Left
Gridlines View Print
Headings View Print
Sheet Options
Bring Forward Send Backward Selection Pane Align
Arrange
A1
L0
L0
DeltaL
number of measurements per set
expected error in the average of a set
Enter the text
Average of set averages
Average of set standard deviations
standard deviation of set averages
error in average
Select destination and press ENTER or choose Paste
Display Settings
100%

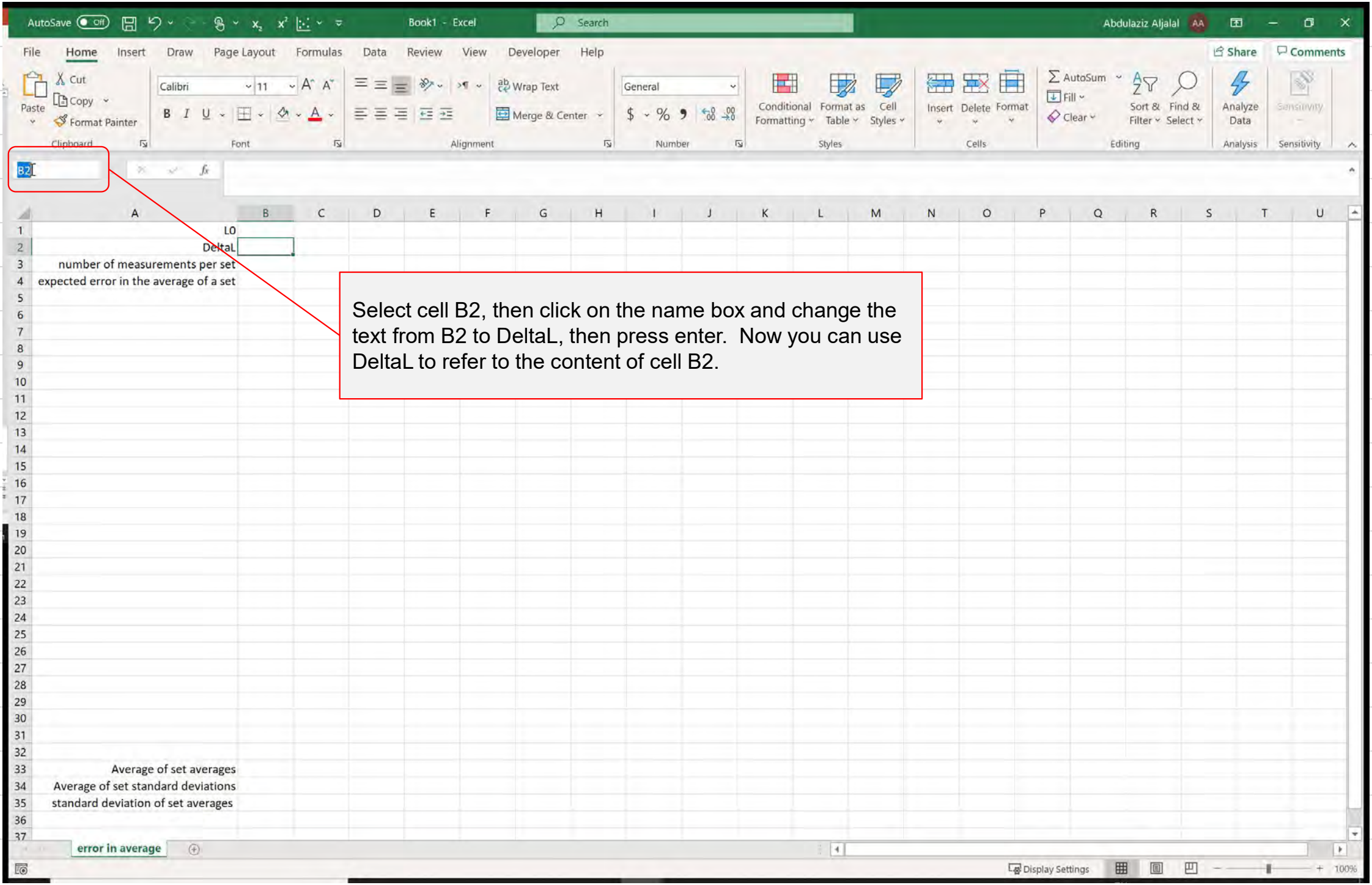


To expand the width of column A to fit the text in it, bring the mouse between column A and column B until the shape of the mouse pointer changes as shown. Double click the mouse.

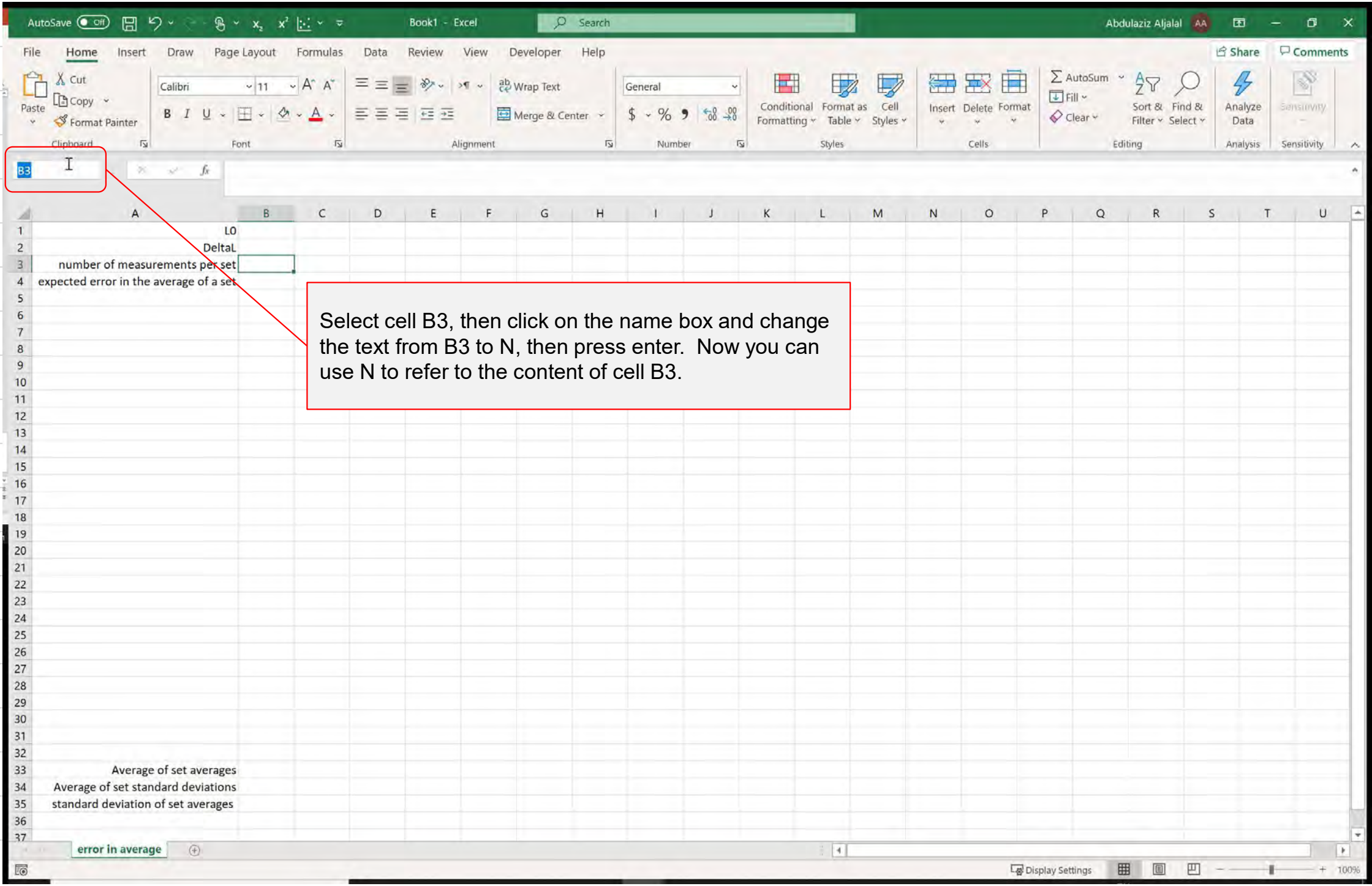

Book1 - Excel
Search
Abdulaziz Aljalal
File Home Insert Draw Page Layout Formulas Data Review View Developer Help
Share Comments
Paste Cut Copy Format Painter
Calibri 11
Wrap Text
Merge & Center
General
Conditional Formatting
Format as Table
Cell Styles
Insert Delete Format
AutoSum Fill Clear
Sort & Filter
Find & Select
Analyze Data
Sensitivity
Clipboard Font Alignment Number Styles Cells Editing Analysis Sensitivity
A1
L0
Select column A by clicking on the top of column A. Then choose Align Right.
L0
DeltaL
number of measurements per set
expected error in the average of a set
Average of set averages
Average of set standard deviations
standard deviation of set averages
error in average
Count: 7
Display Settings
100%



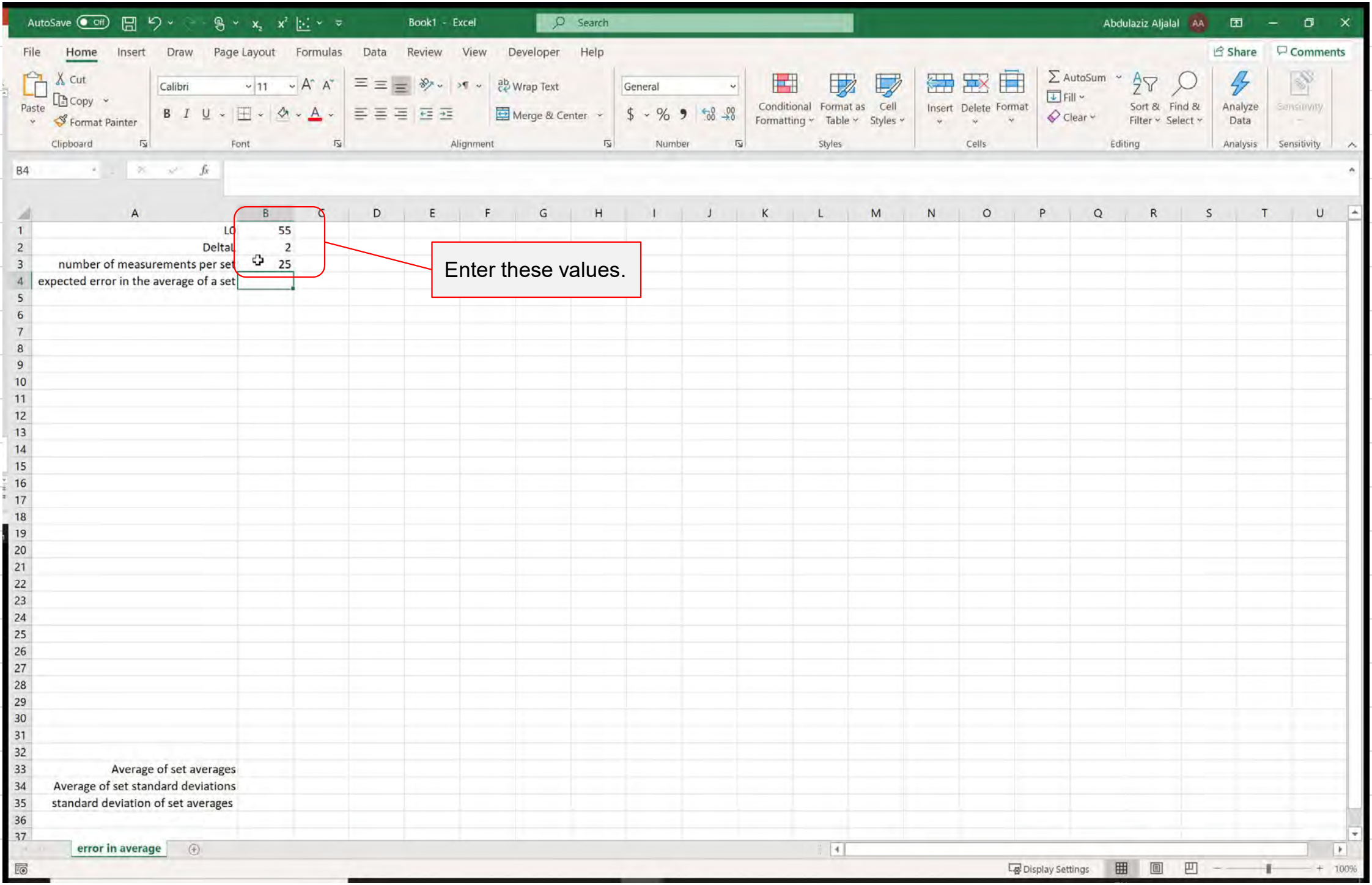
Select cell B1, then click on the name box and change the text from B1 to L0, then press enter. Now you can use L0 to refer to the content of cell B1.

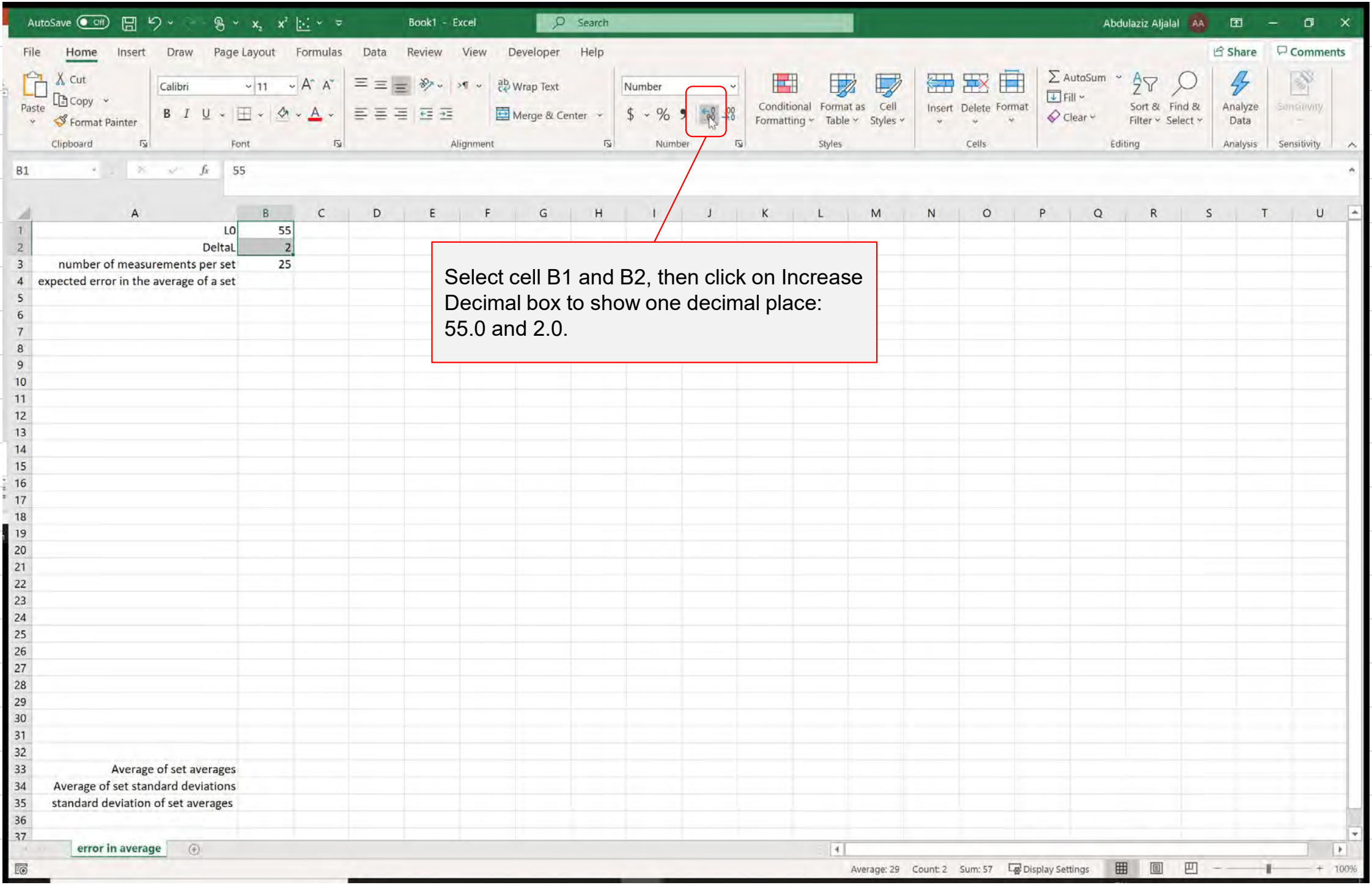


Select cell B2, then click on the name box and change the text from B2 to DeltaL, then press enter. Now you can use DeltaL to refer to the content of cell B2.

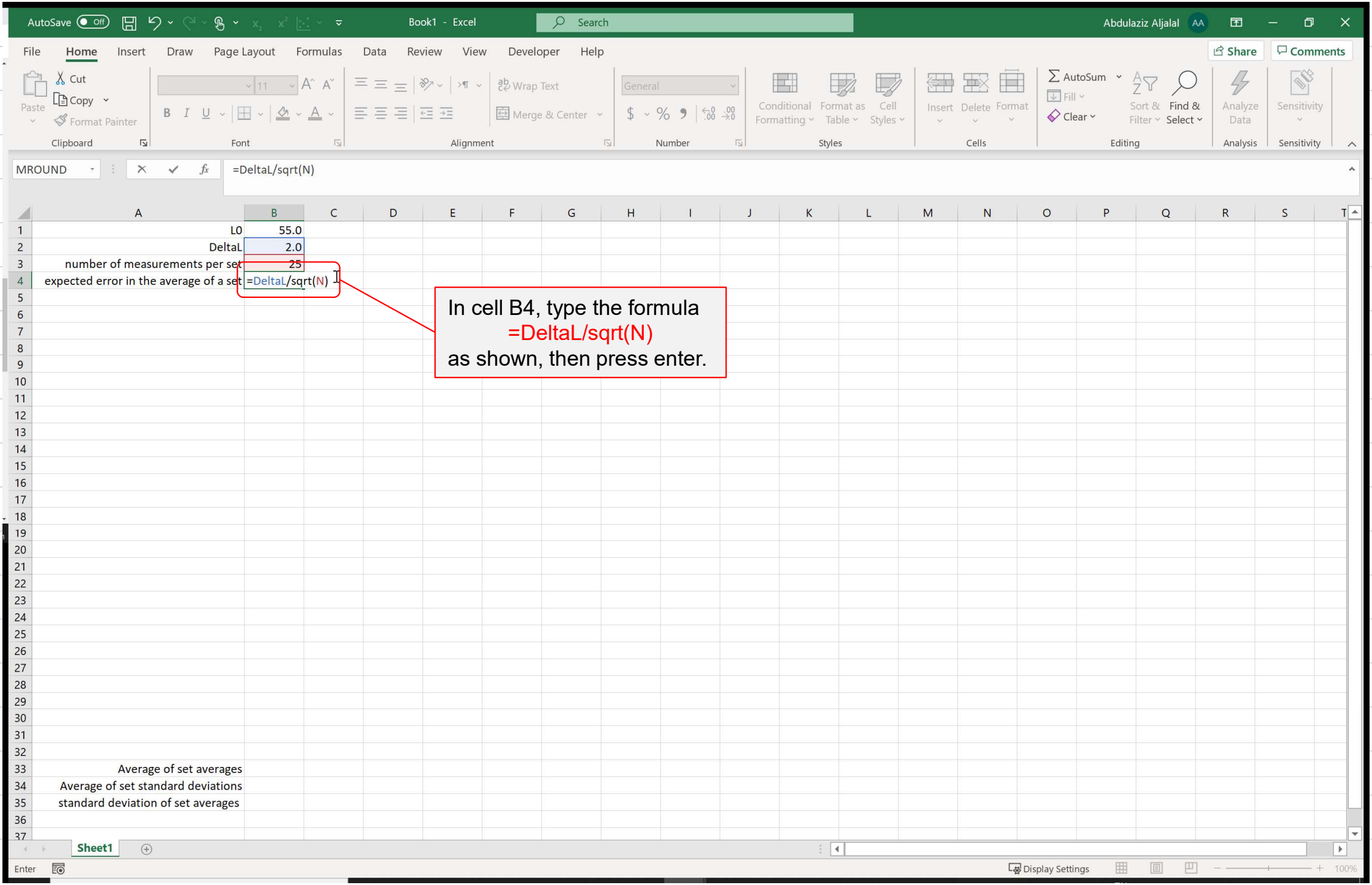


Select cell B3, then click on the name box and change the text from B3 to N, then press enter. Now you can use N to refer to the content of cell B3.

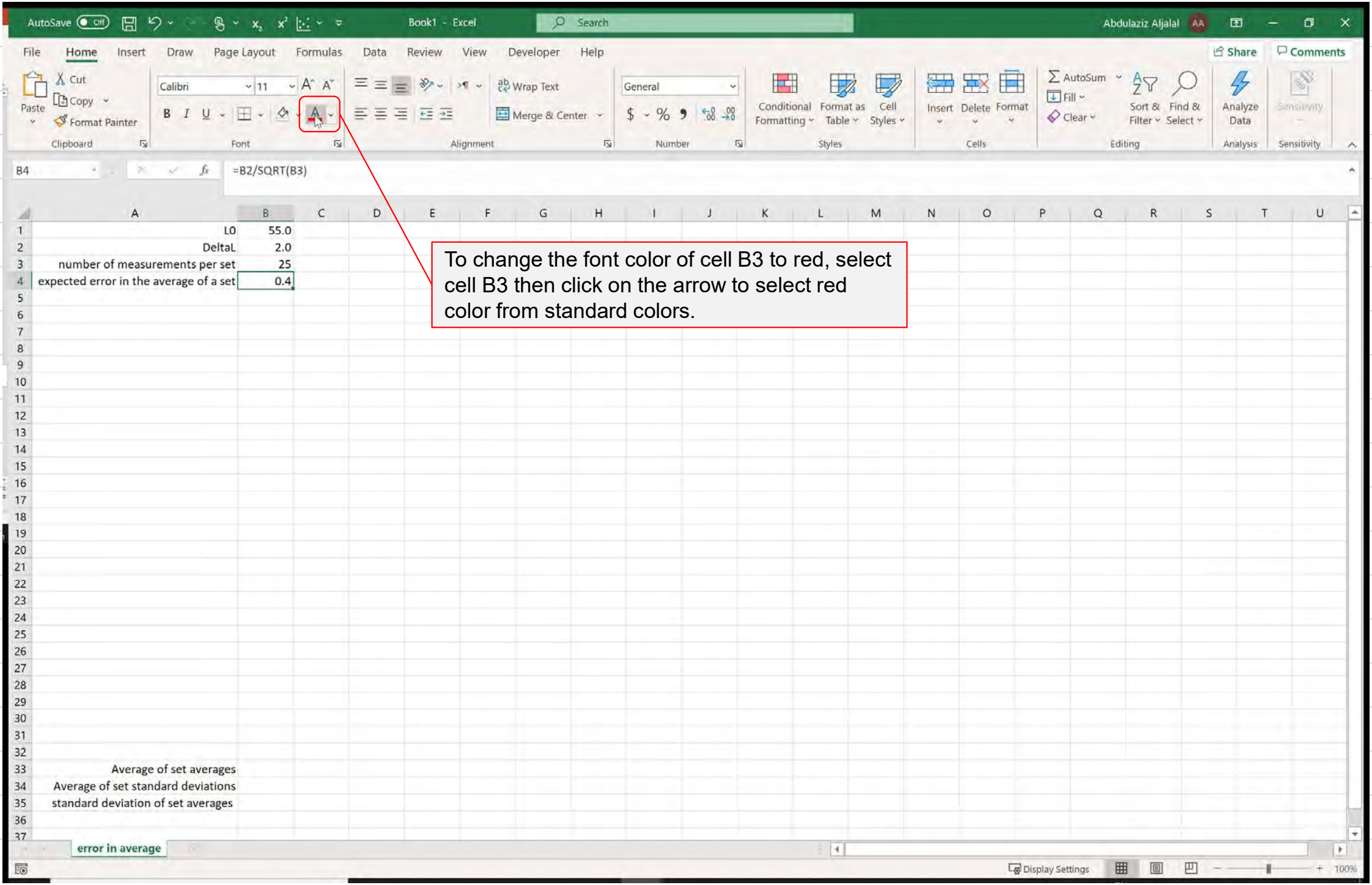

AutoSave
Book1 - Excel
Search
Abdulaziz Aljalal
File Home Insert Draw Page Layout Formulas Data Review View Developer Help
Share Comments
Paste Cut Copy Format Painter
Calibri 11
Wrap Text
Merge & Center
General
Conditional Formatting
Format as Table
Cell Styles
Insert Delete Format
AutoSum Fill Clear
Sort & Filter
Find & Select
Analyze Data
Sensitivity
Clipboard Font Alignment Number Styles Cells Editing Analysis Sensitivity
B4
A B C D E F G H I J K L M N O P Q R S T U
1 L0 55
2 DeltaL 2
3 number of measurements per set 25
4 expected error in the average of a set
Enter these values.
33 Average of set averages
34 Average of set standard deviations
35 standard deviation of set averages
error in average
Display Settings
100%

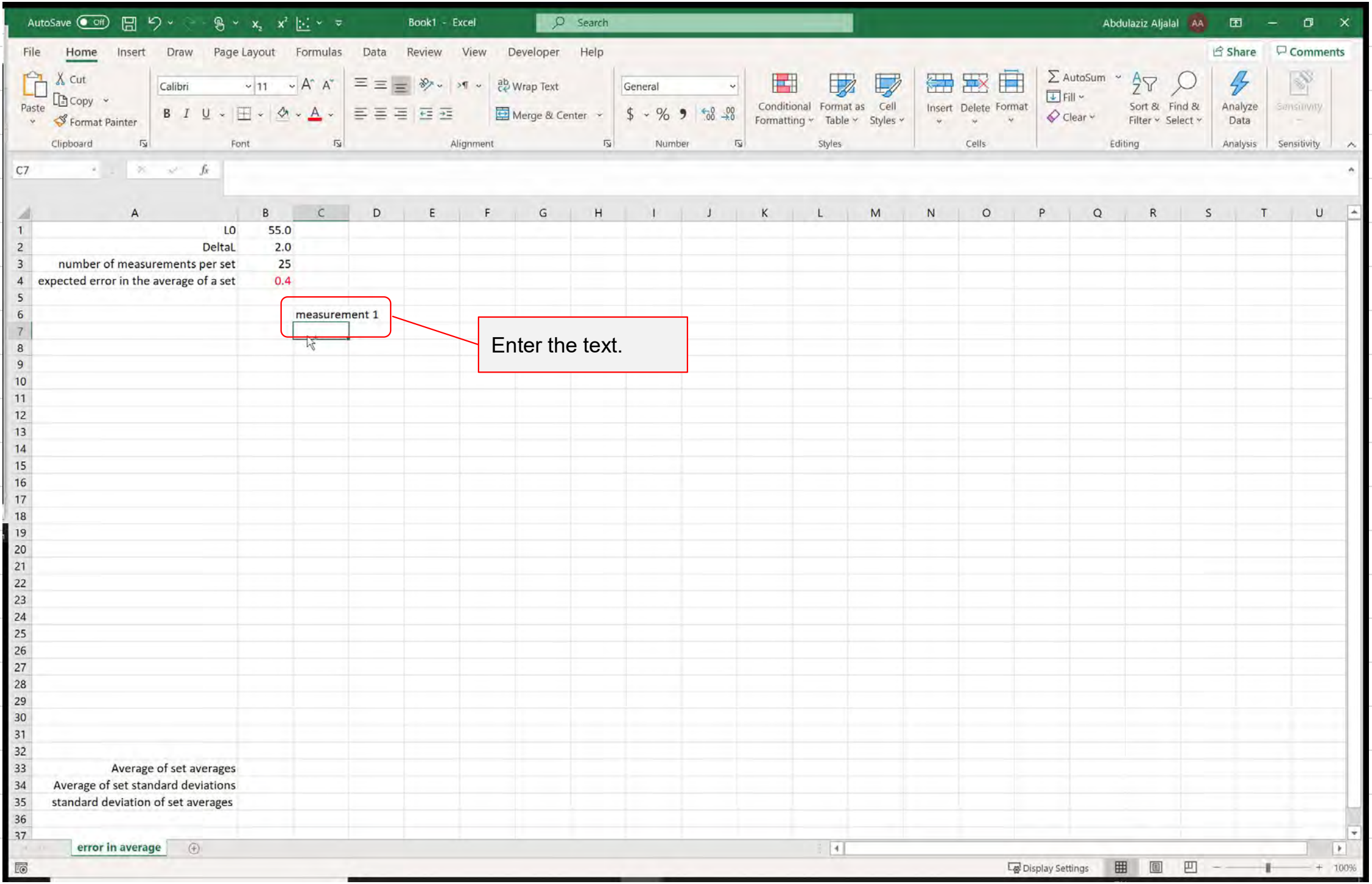


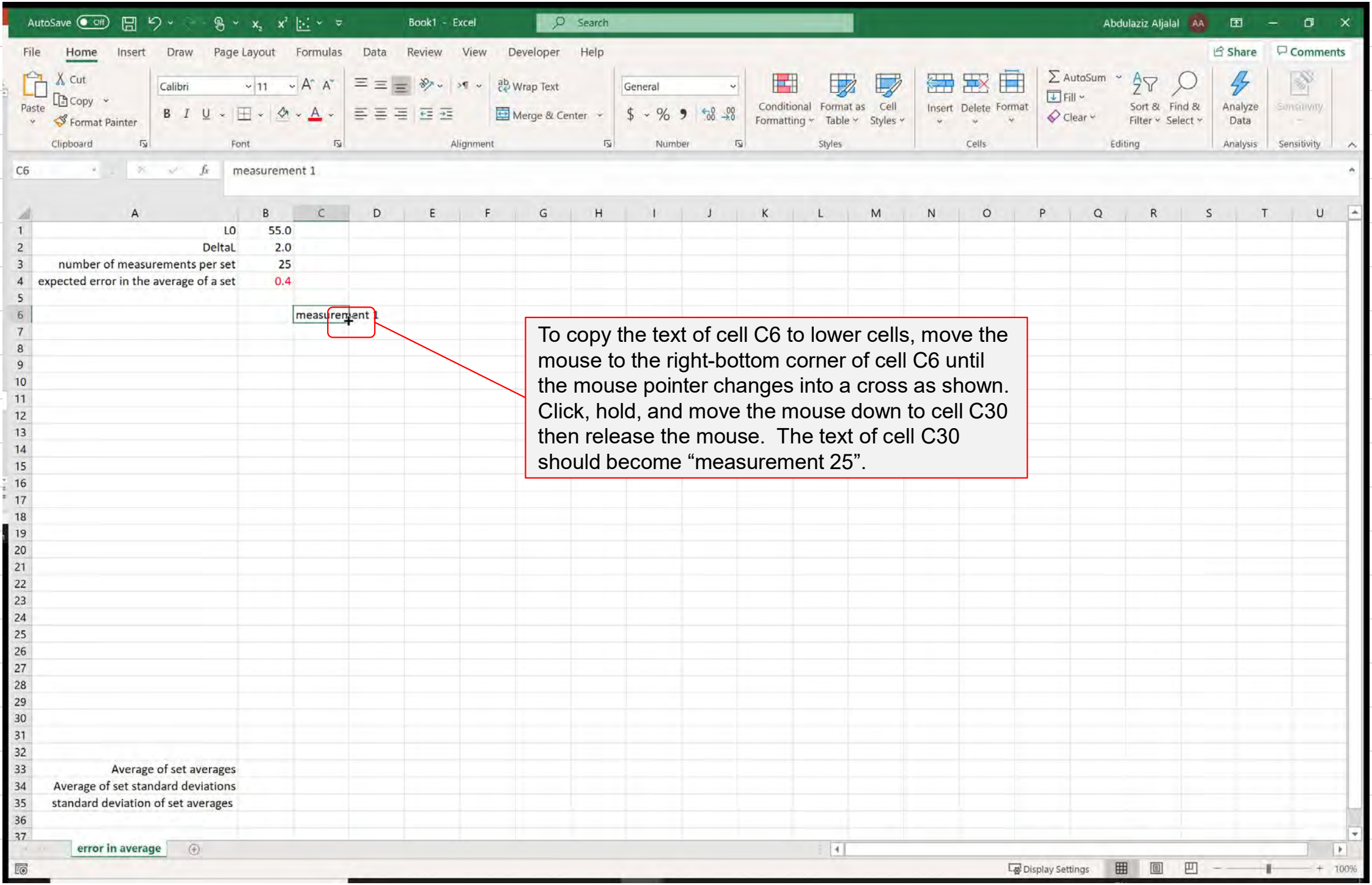
Select cell B1 and B2, then click on Increase Decimal box to show one decimal place: 55.0 and 2.0.



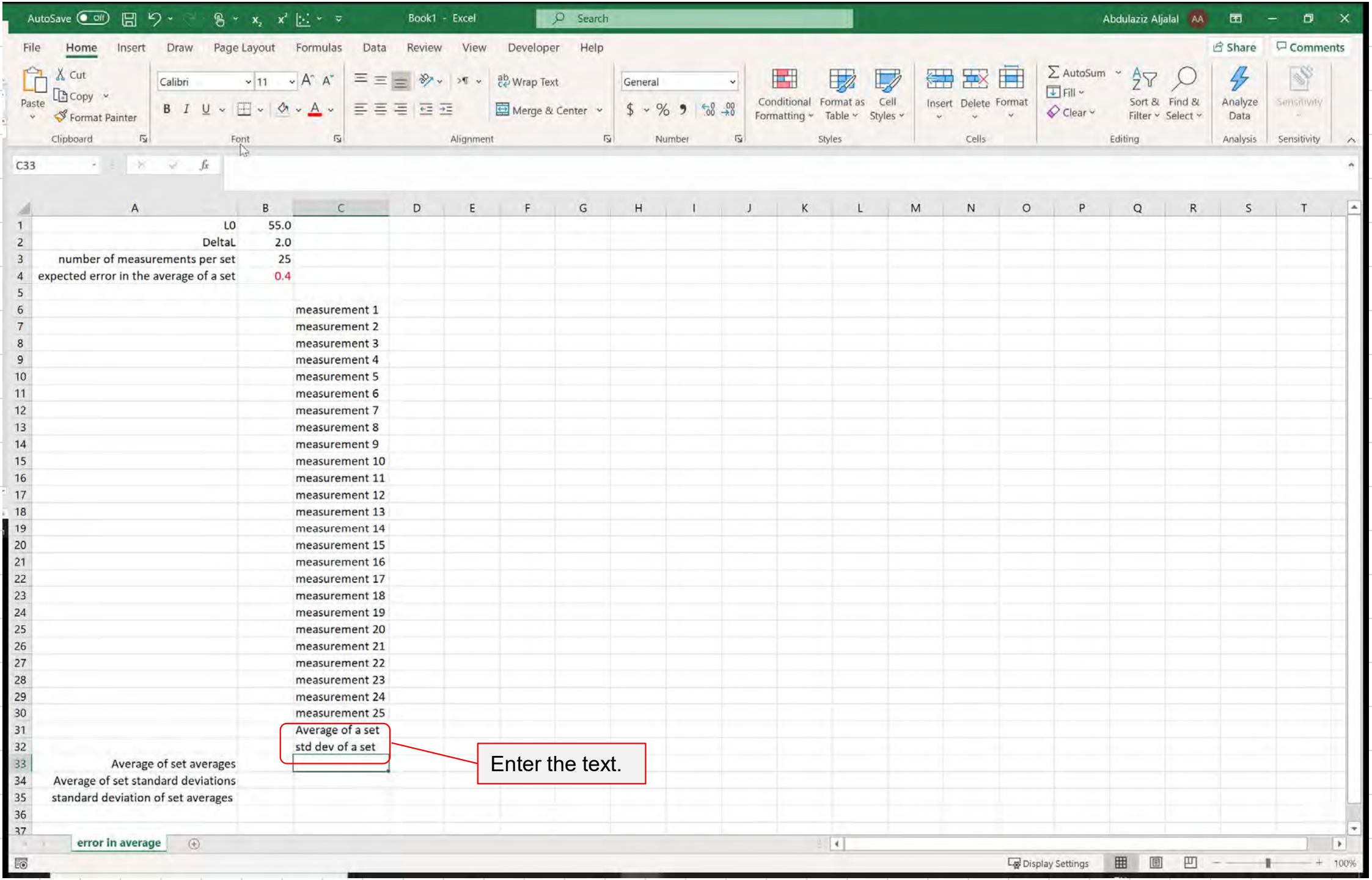
In cell B4, type the formula
=DeltaL/sqrt(N)
as shown, then press enter.

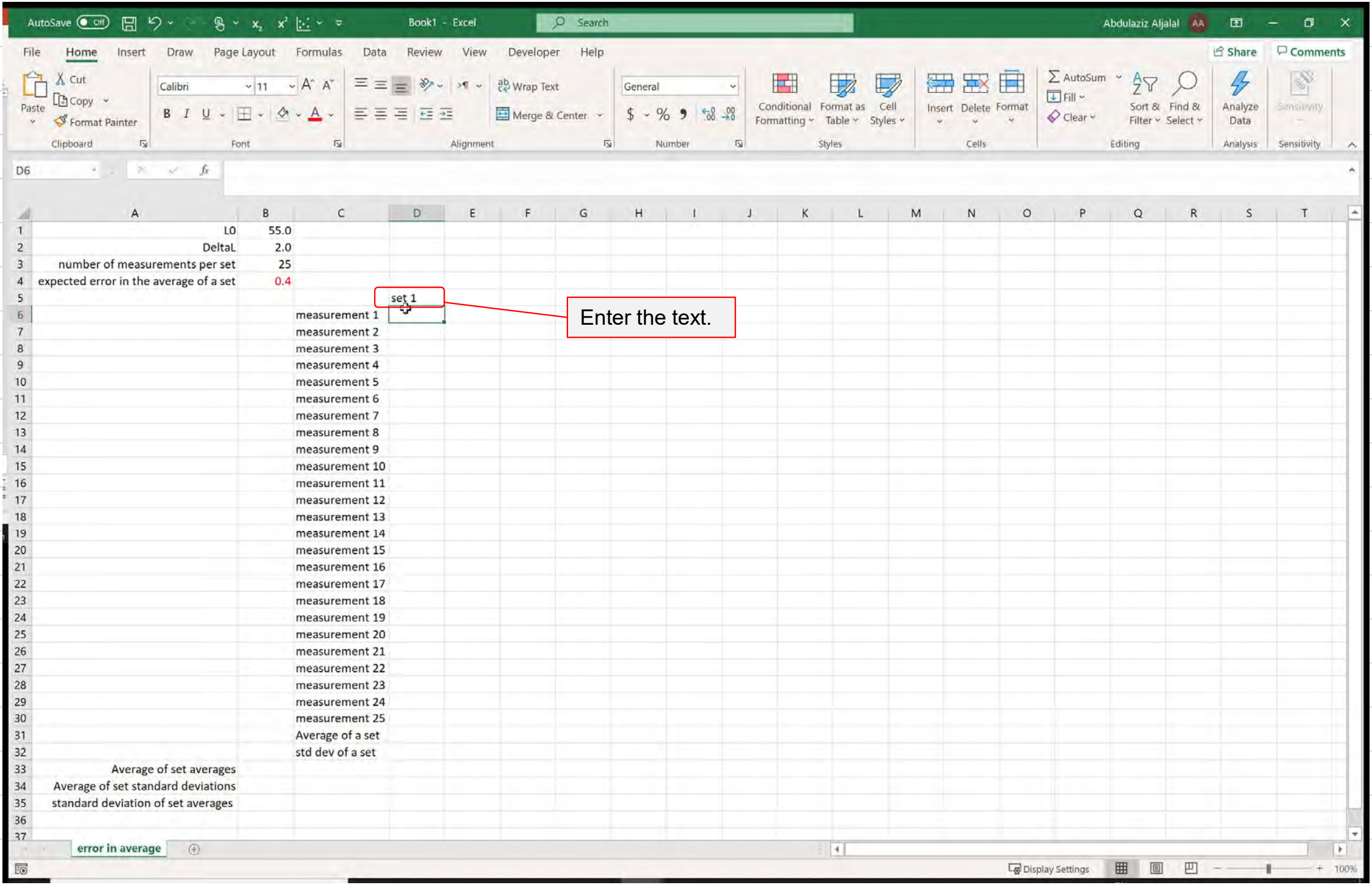

AutoSave
Book1 - Excel
Search
Abdulaziz Aljalal
File Home Insert Draw Page Layout Formulas Data Review View Developer Help
Share Comments
Cut Copy Format Painter Paste
Calibri 11
Wrap Text
Merge & Center
General
Conditional Formatting
Format as Table
Cell Styles
Insert Delete Format
AutoSum Fill Clear
Sort & Filter
Find & Select
Analyze Data
Sensitivity
Clipboard Font Alignment Number Styles Cells Editing Analysis Sensitivity
B4
=B2/SQRT(B3)
To change the font color of cell B3 to red, select cell B3 then click on the arrow to select red color from standard colors.
L0 55.0
DeltaL 2.0
number of measurements per set 25
expected error in the average of a set 0.4
Average of set averages
Average of set standard deviations
standard deviation of set averages
error in average
Display Settings
100%


AutoSave
Book1 - Excel
Search
Abdulaziz Aljalal
File Home Insert Draw Page Layout Formulas Data Review View Developer Help
Share Comments
Paste Cut Copy Format Painter
Calibri 11
Wrap Text
Merge & Center
General
Conditional Formatting
Format as Table
Cell Styles
Insert Delete Format
AutoSum Fill Clear
Sort & Filter
Find & Select
Analyze Data
Sensitivity
Clipboard Font Alignment Number Styles Cells Editing Analysis Sensitivity
C7
A B C D E F G H I J K L M N O P Q R S T U
1 L0 55.0
2 DeltaL 2.0
3 number of measurements per set 25
4 expected error in the average of a set 0.4
6 measurement 1
Enter the text.
33 Average of set averages
34 Average of set standard deviations
35 standard deviation of set averages
error in average
Display Settings
100%

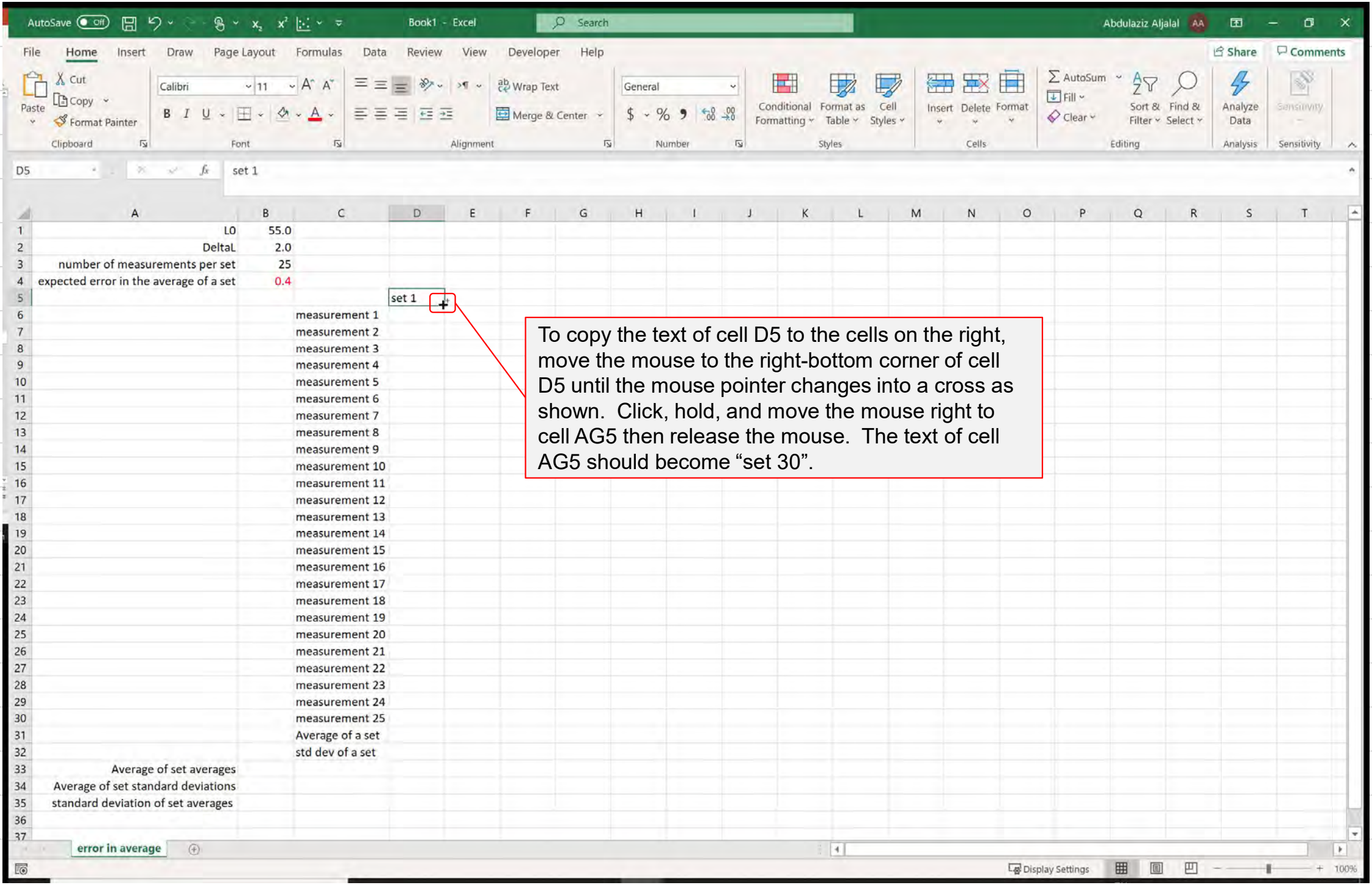


To copy the text of cell C6 to lower cells, move the mouse to the right-bottom corner of cell C6 until the mouse pointer changes into a cross as shown. Click, hold, and move the mouse down to cell C30 then release the mouse. The text of cell C30 should become “measurement 25”.

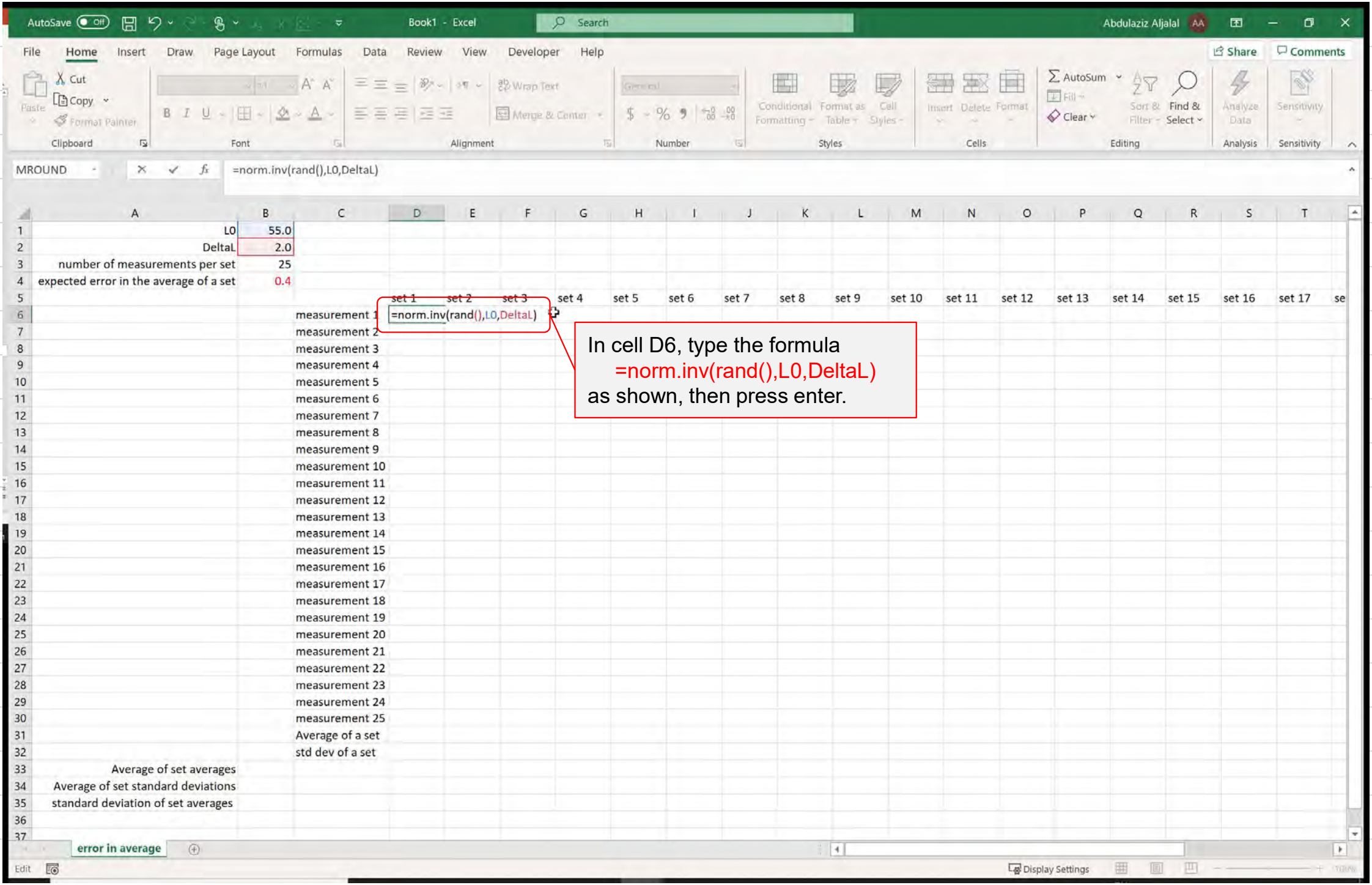

AutoSave
Book1 - Excel
Search
Abdulaziz Aljalal
File Home Insert Draw Page Layout Formulas Data Review View Developer Help
Share Comments
Paste Cut Copy Format Painter
Calibri 11
Wrap Text
General
Merge & Center
Conditional Formatting
Format as Table
Cell Styles
Insert Delete Format
AutoSum Fill Clear
Sort & Filter
Find & Select
Analyze Data
Sensitivity
Clipboard Font Alignment Number Styles Cells Editing Analysis Sensitivity
C33
L0 55.0
DeltaL 2.0
number of measurements per set 25
expected error in the average of a set 0.4
measurement 1
measurement 2
measurement 3
measurement 4
measurement 5
measurement 6
measurement 7
measurement 8
measurement 9
measurement 10
measurement 11
measurement 12
measurement 13
measurement 14
measurement 15
measurement 16
measurement 17
measurement 18
measurement 19
measurement 20
measurement 21
measurement 22
measurement 23
measurement 24
measurement 25
Average of a set
std dev of a set
Average of set averages
Average of set standard deviations
standard deviation of set averages
Enter the text.
error in average
Display Settings
100%

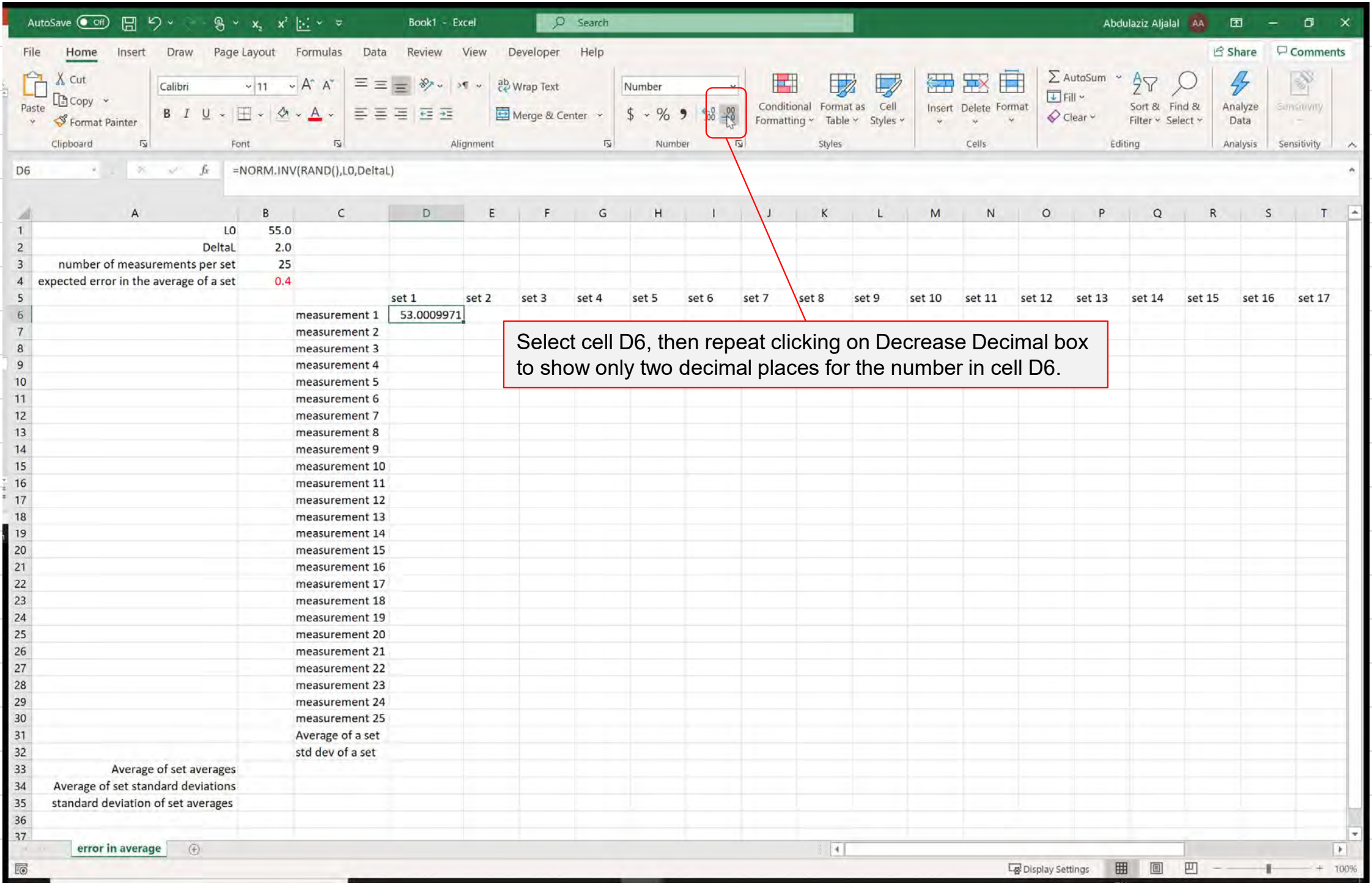


	A	B	C
1	L0	55.0	
2	DeltaL	2.0	
3	number of measurements per set	25	
4	expected error in the average of a set	0.4	
5			
6			measurement 1
7			measurement 2
8			measurement 3
9			measurement 4
10			measurement 5
11			measurement 6
12			measurement 7
13			measurement 8
14			measurement 9
15			measurement 10
16			measurement 11
17			measurement 12
18			measurement 13
19			measurement 14
20			measurement 15
21			measurement 16
22			measurement 17
23			measurement 18
24			measurement 19
25			measurement 20
26			measurement 21
27			measurement 22
28			measurement 23
29			measurement 24
30			measurement 25
31			Average of a set
32			std dev of a set
33	Average of set averages		
34	Average of set standard deviations		
35	standard deviation of set averages		
36			
37			

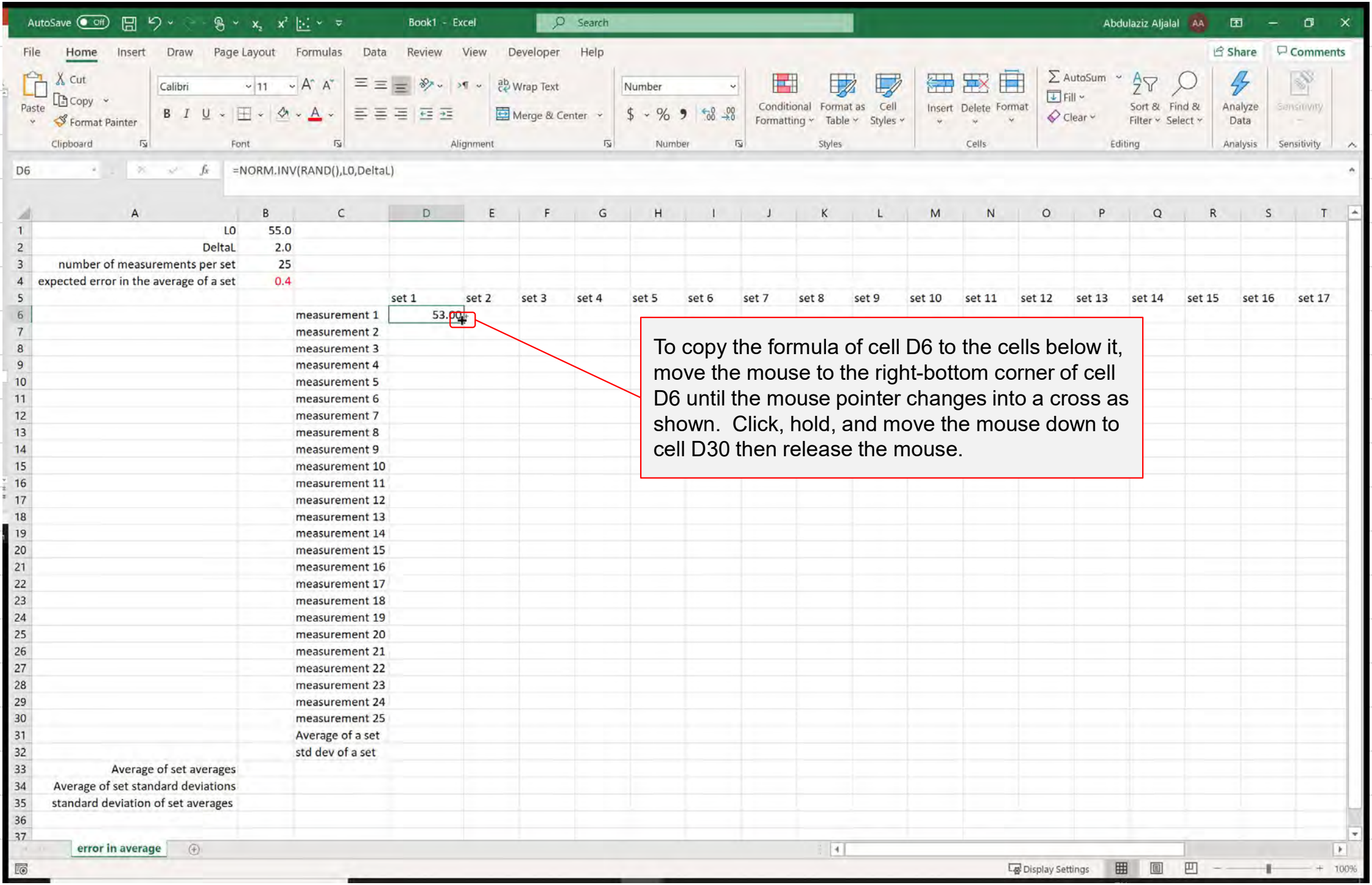


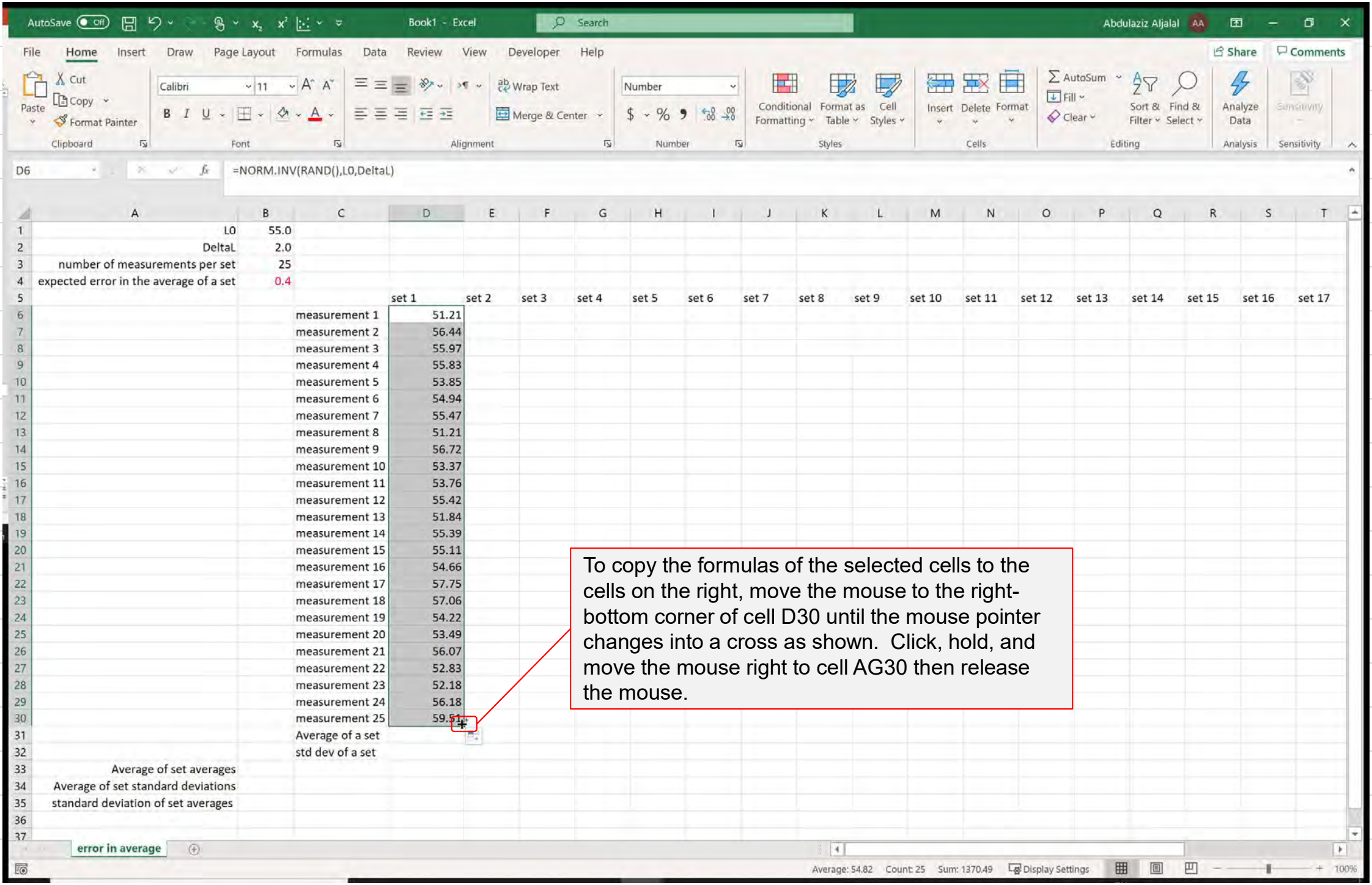
	A	B	C	D
1	L0	55.0		
2	DeltaL	2.0		
3	number of measurements per set	25		
4	expected error in the average of a set	0.4		
5				set 1
6			measurement 1	
7			measurement 2	
8			measurement 3	
9			measurement 4	
10			measurement 5	
11			measurement 6	
12			measurement 7	
13			measurement 8	
14			measurement 9	
15			measurement 10	
16			measurement 11	
17			measurement 12	
18			measurement 13	
19			measurement 14	
20			measurement 15	
21			measurement 16	
22			measurement 17	
23			measurement 18	
24			measurement 19	
25			measurement 20	
26			measurement 21	
27			measurement 22	
28			measurement 23	
29			measurement 24	
30			measurement 25	
31			Average of a set	
32			std dev of a set	
33	Average of set averages			
34	Average of set standard deviations			
35	standard deviation of set averages			
36				
37				

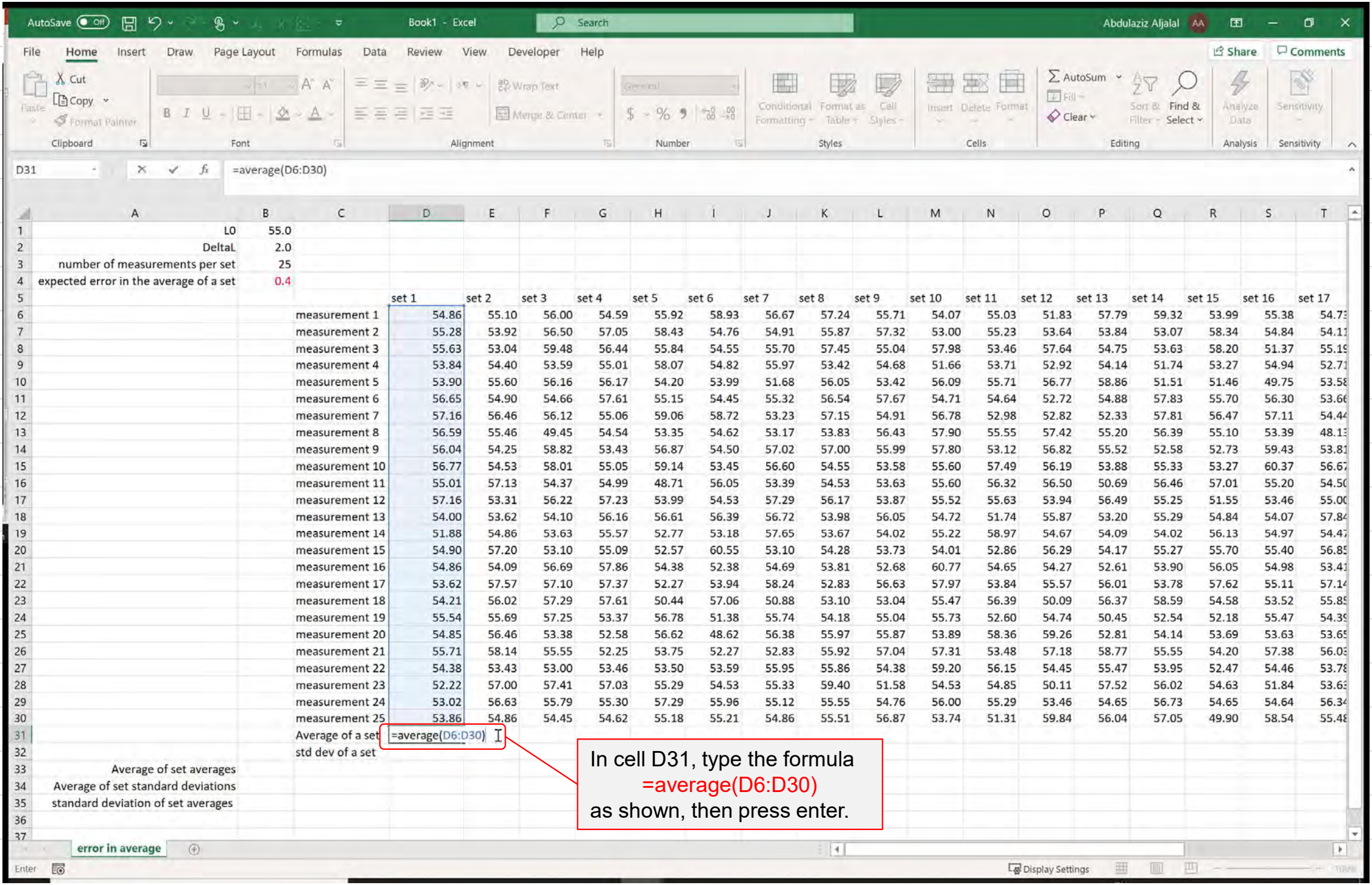

Book1 - Excel
Abdulaziz Aljalal
File Home Insert Draw Page Layout Formulas Data Review View Developer Help
Share Comments
MROUND
=norm.inv(rand(),L0,DeltaL)
L0 55.0
DeltaL 2.0
number of measurements per set 25
expected error in the average of a set 0.4
set 1 set 2 set 3 set 4 set 5 set 6 set 7 set 8 set 9 set 10 set 11 set 12 set 13 set 14 set 15 set 16 set 17
measurement 1 =norm.inv(rand(),L0,DeltaL)
measurement 2
measurement 3
measurement 4
measurement 5
measurement 6
measurement 7
measurement 8
measurement 9
measurement 10
measurement 11
measurement 12
measurement 13
measurement 14
measurement 15
measurement 16
measurement 17
measurement 18
measurement 19
measurement 20
measurement 21
measurement 22
measurement 23
measurement 24
measurement 25
Average of a set
std dev of a set
Average of set averages
Average of set standard deviations
standard deviation of set averages
In cell D6, type the formula
=norm.inv(rand(),L0,DeltaL)
as shown, then press enter.
error in average
Edit
Display Settings



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
1	L0	55.0																		
2	DeltaL	2.0																		
3	number of measurements per set	25																		
4	expected error in the average of a set	0.4																		
5				set 1	set 2	set 3	set 4	set 5	set 6	set 7	set 8	set 9	set 10	set 11	set 12	set 13	set 14	set 15	set 16	set 17
6			measurement 1	53.0009971																
7			measurement 2																	
8			measurement 3																	
9			measurement 4																	
10			measurement 5																	
11			measurement 6																	
12			measurement 7																	
13			measurement 8																	
14			measurement 9																	
15			measurement 10																	
16			measurement 11																	
17			measurement 12																	
18			measurement 13																	
19			measurement 14																	
20			measurement 15																	
21			measurement 16																	
22			measurement 17																	
23			measurement 18																	
24			measurement 19																	
25			measurement 20																	
26			measurement 21																	
27			measurement 22																	
28			measurement 23																	
29			measurement 24																	
30			measurement 25																	
31			Average of a set																	
32			std dev of a set																	
33	Average of set averages																			
34	Average of set standard deviations																			
35	standard deviation of set averages																			
36																				
37																				

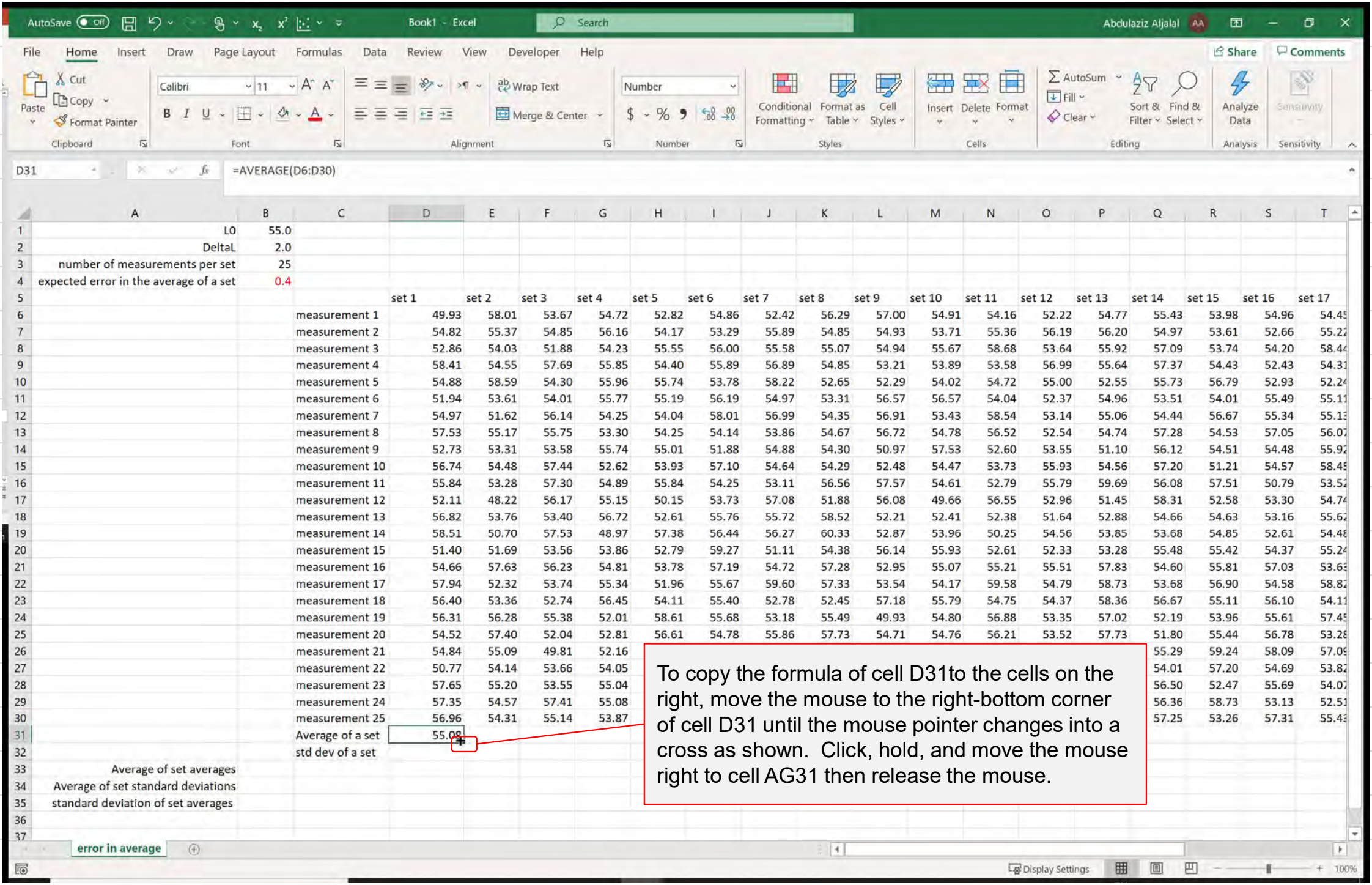

AutoSave
Book1 - Excel
Search
Abdulaziz Aljalal
File Home Insert Draw Page Layout Formulas Data Review View Developer Help
Share Comments
Paste Cut Copy Format Painter
Calibri 11
Wrap Text
Merge & Center
Number
Conditional Formatting
Format as Table
Cell Styles
Insert Delete Format
AutoSum Fill Clear
Sort & Filter
Find & Select
Analyze Data
Sensitivity
Clipboard Font Alignment Number Styles Cells Editing Analysis Sensitivity
D6
=NORM.INV(RAND(),L0,DeltaL)
L0 55.0
DeltaL 2.0
number of measurements per set 25
expected error in the average of a set 0.4
set 1 set 2 set 3 set 4 set 5 set 6 set 7 set 8 set 9 set 10 set 11 set 12 set 13 set 14 set 15 set 16 set 17
measurement 1 53.00
measurement 2
measurement 3
measurement 4
measurement 5
measurement 6
measurement 7
measurement 8
measurement 9
measurement 10
measurement 11
measurement 12
measurement 13
measurement 14
measurement 15
measurement 16
measurement 17
measurement 18
measurement 19
measurement 20
measurement 21
measurement 22
measurement 23
measurement 24
measurement 25
Average of a set
std dev of a set
Average of set averages
Average of set standard deviations
standard deviation of set averages
To copy the formula of cell D6 to the cells below it, move the mouse to the right-bottom corner of cell D6 until the mouse pointer changes into a cross as shown. Click, hold, and move the mouse down to cell D30 then release the mouse.
error in average
Display Settings
100%


AutoSave
Book1 - Excel
Search
Abdulaziz Aljalal
File Home Insert Draw Page Layout Formulas Data Review View Developer Help
Share Comments
Paste Cut Copy Format Painter
Calibri 11
Wrap Text
Merge & Center
Number
Conditional Formatting
Format as Table
Cell Styles
Insert Delete Format
AutoSum Fill Clear
Sort & Filter
Find & Select
Analyze Data
Sensitivity
Clipboard Font Alignment Number Styles Cells Editing Analysis Sensitivity
D6
=NORM.INV(RAND(),L0,DeltaL)
L0 55.0
DeltaL 2.0
number of measurements per set 25
expected error in the average of a set 0.4
set 1 set 2 set 3 set 4 set 5 set 6 set 7 set 8 set 9 set 10 set 11 set 12 set 13 set 14 set 15 set 16 set 17
measurement 1 51.21
measurement 2 56.44
measurement 3 55.97
measurement 4 55.83
measurement 5 53.85
measurement 6 54.94
measurement 7 55.47
measurement 8 51.21
measurement 9 56.72
measurement 10 53.37
measurement 11 53.76
measurement 12 55.42
measurement 13 51.84
measurement 14 55.39
measurement 15 55.11
measurement 16 54.66
measurement 17 57.75
measurement 18 57.06
measurement 19 54.22
measurement 20 53.49
measurement 21 56.07
measurement 22 52.83
measurement 23 52.18
measurement 24 56.18
measurement 25 59.51
Average of a set
std dev of a set
Average of set averages
Average of set standard deviations
standard deviation of set averages
To copy the formulas of the selected cells to the cells on the right, move the mouse to the right-bottom corner of cell D30 until the mouse pointer changes into a cross as shown. Click, hold, and move the mouse right to cell AG30 then release the mouse.
error in average
Average: 54.82 Count: 25 Sum: 1370.49 Display Settings 100%



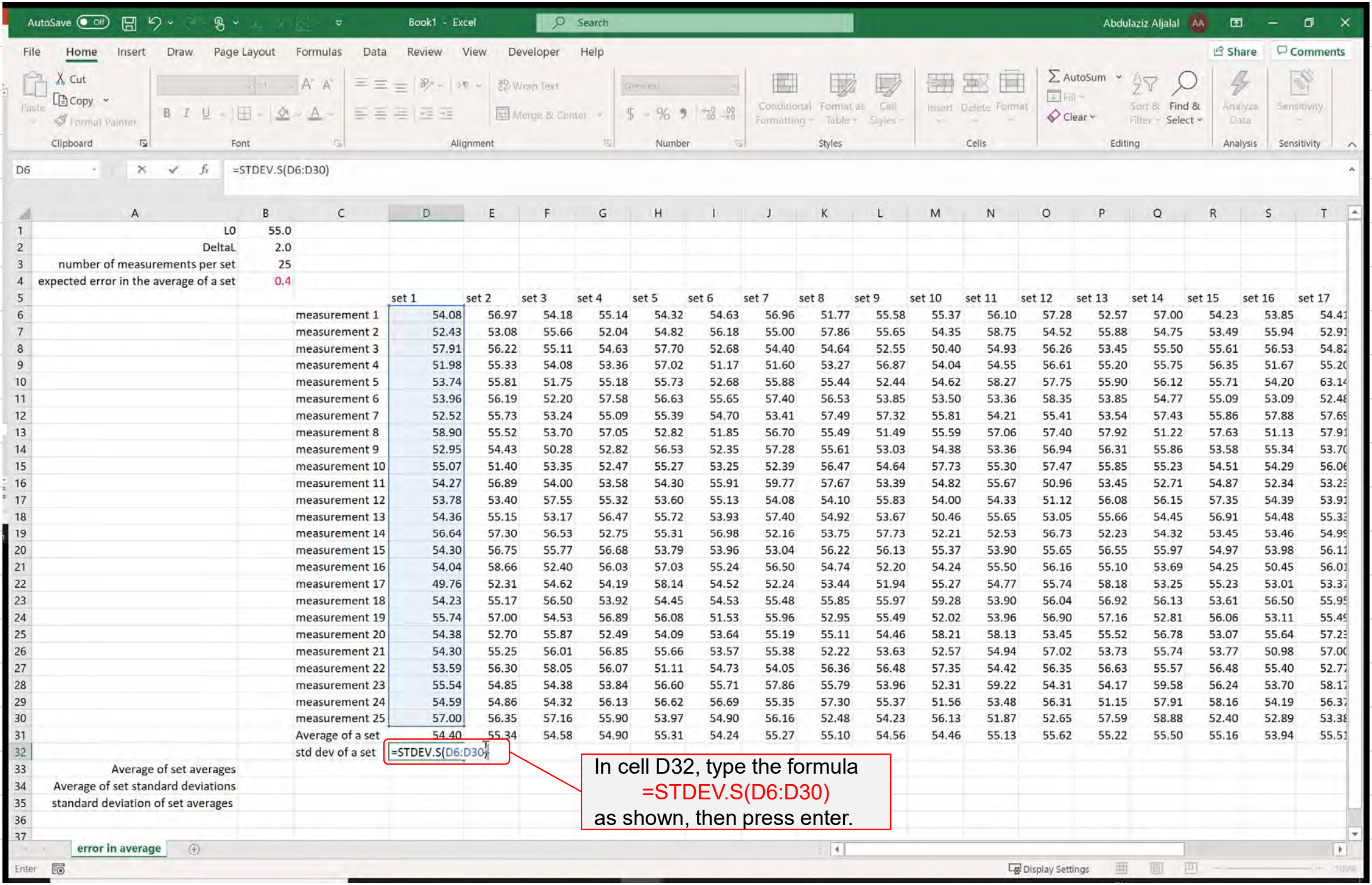
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
1	L0	55.0																		
2	DeltaL	2.0																		
3	number of measurements per set	25																		
4	expected error in the average of a set	0.4																		
5				set 1	set 2	set 3	set 4	set 5	set 6	set 7	set 8	set 9	set 10	set 11	set 12	set 13	set 14	set 15	set 16	set 17
6			measurement 1	54.86	55.10	56.00	54.59	55.92	58.93	56.67	57.24	55.71	54.07	55.03	51.83	57.79	59.32	53.99	55.38	54.73
7			measurement 2	55.28	53.92	56.50	57.05	58.43	54.76	54.91	55.87	57.32	53.00	55.23	53.64	53.84	53.07	58.34	54.84	54.11
8			measurement 3	55.63	53.04	59.48	56.44	55.84	54.55	55.70	57.45	55.04	57.98	53.46	57.64	54.75	53.63	58.20	51.37	55.19
9			measurement 4	53.84	54.40	53.59	55.01	58.07	54.82	55.97	53.42	54.68	51.66	53.71	52.92	54.14	51.74	53.27	54.94	52.71
10			measurement 5	53.90	55.60	56.16	56.17	54.20	53.99	51.68	56.05	53.42	56.09	55.71	56.77	58.86	51.51	51.46	49.75	53.58
11			measurement 6	56.65	54.90	54.66	57.61	55.15	54.45	55.32	56.54	57.67	54.71	54.64	52.72	54.88	57.83	55.70	56.30	53.66
12			measurement 7	57.16	56.46	56.12	55.06	59.06	58.72	53.23	57.15	54.91	56.78	52.98	52.82	52.33	57.81	56.47	57.11	54.44
13			measurement 8	56.59	55.46	49.45	54.54	53.35	54.62	53.17	53.83	56.43	57.90	55.55	57.42	55.20	56.39	55.10	53.39	48.13
14			measurement 9	56.04	54.25	58.82	53.43	56.87	54.50	57.02	57.00	55.99	57.80	53.12	56.82	55.52	52.58	52.73	59.43	53.81
15			measurement 10	56.77	54.53	58.01	55.05	59.14	53.45	56.60	54.55	53.58	55.60	57.49	56.19	53.88	55.33	53.27	60.37	56.67
16			measurement 11	55.01	57.13	54.37	54.99	48.71	56.05	53.39	54.53	53.63	55.60	56.32	56.50	50.69	56.46	57.01	55.20	54.50
17			measurement 12	57.16	53.31	56.22	57.23	53.99	54.53	57.29	56.17	53.87	55.52	55.63	53.94	56.49	55.25	51.55	53.46	55.00
18			measurement 13	54.00	53.62	54.10	56.16	56.61	56.39	56.72	53.98	56.05	54.72	51.74	55.87	53.20	55.29	54.84	54.07	57.84
19			measurement 14	51.88	54.86	53.63	55.57	52.77	53.18	57.65	53.67	54.02	55.22	58.97	54.67	54.09	54.02	56.13	54.97	54.47
20			measurement 15	54.90	57.20	53.10	55.09	52.57	60.55	53.10	54.28	53.73	54.01	52.86	56.29	54.17	55.27	55.70	55.40	56.85
21			measurement 16	54.86	54.09	56.69	57.86	54.38	52.38	54.69	53.81	52.68	60.77	54.65	54.27	52.61	53.90	56.05	54.98	53.41
22			measurement 17	53.62	57.57	57.10	57.37	52.27	53.94	58.24	52.83	56.63	57.97	53.84	55.57	56.01	53.78	57.62	55.11	57.14
23			measurement 18	54.21	56.02	57.29	57.61	50.44	57.06	50.88	53.10	53.04	55.47	56.39	50.09	56.37	58.59	54.58	53.52	55.85
24			measurement 19	55.54	55.69	57.25	53.37	56.78	51.38	55.74	54.18	55.04	55.73	52.60	54.74	50.45	52.54	52.18	55.47	54.39
25			measurement 20	54.85	56.46	53.38	52.58	56.62	48.62	56.38	55.97	55.87	53.89	58.36	59.26	52.81	54.14	53.69	53.63	53.65
26			measurement 21	55.71	58.14	55.55	52.25	53.75	52.27	52.83	55.92	57.04	57.31	53.48	57.18	58.77	55.55	54.20	57.38	56.03
27			measurement 22	54.38	53.43	53.00	53.46	53.50	53.59	55.95	55.86	54.38	59.20	56.15	54.45	55.47	53.95	52.47	54.46	53.78
28			measurement 23	52.22	57.00	57.41	57.03	55.29	54.53	55.33	59.40	51.58	54.53	54.85	50.11	57.52	56.02	54.63	51.84	53.63
29			measurement 24	53.02	56.63	55.79	55.30	57.29	55.96	55.12	55.55	54.76	56.00	55.29	53.46	54.65	56.73	54.65	54.64	56.34
30			measurement 25	53.86	54.86	54.45	54.62	55.18	55.21	54.86	55.51	56.87	53.74	51.31	59.84	56.04	57.05	49.90	58.54	55.48
31			Average of a set	=average(D6:D30)																
32			std dev of a set																	
33	Average of set averages																			
34	Average of set standard deviations																			
35	standard deviation of set averages																			
36																				
37																				

In cell D31, type the formula
=average(D6:D30)
as shown, then press enter.



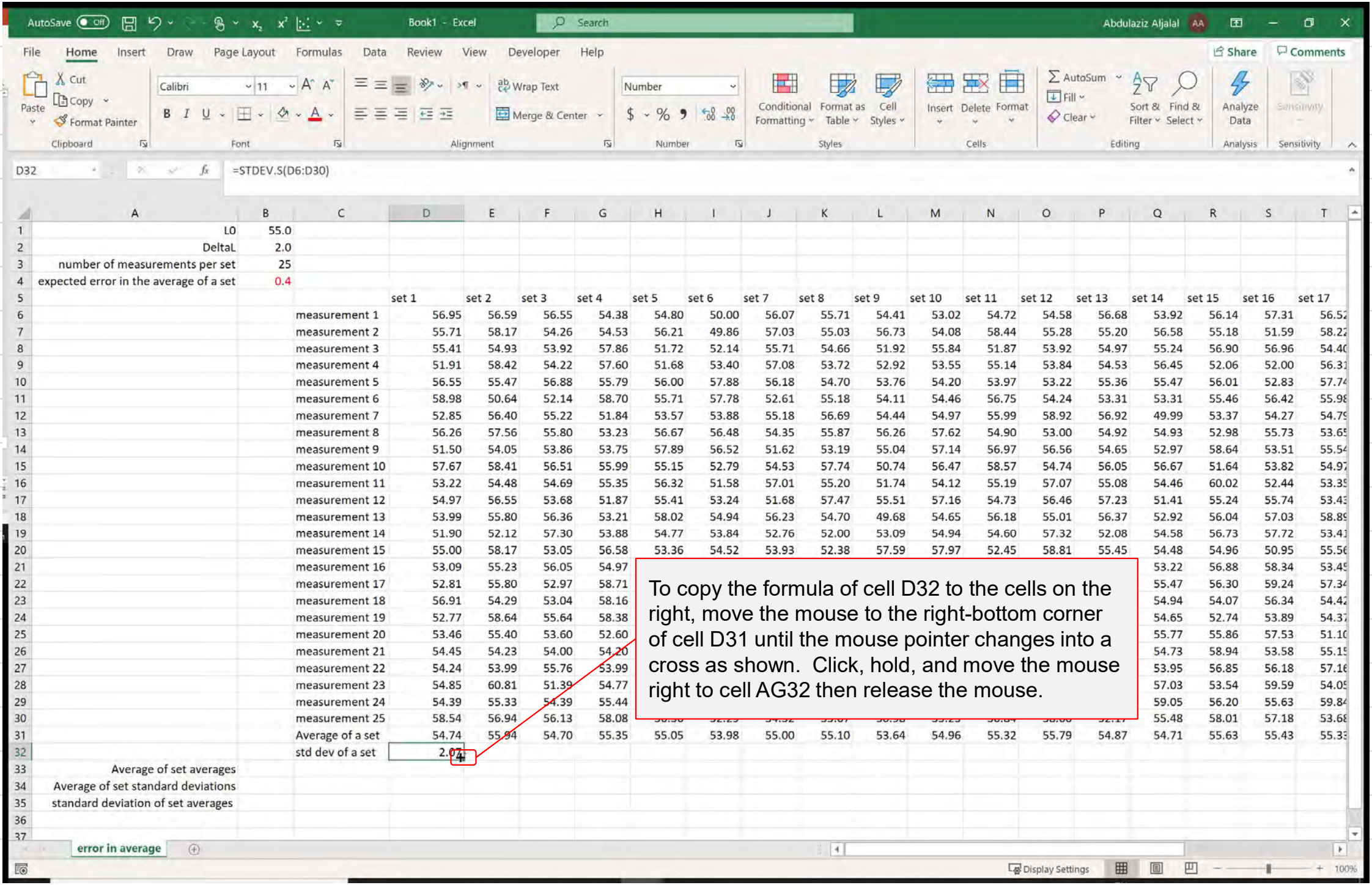
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
1	L0	55.0																		
2	DeltaL	2.0																		
3	number of measurements per set	25																		
4	expected error in the average of a set	0.4																		
5				set 1	set 2	set 3	set 4	set 5	set 6	set 7	set 8	set 9	set 10	set 11	set 12	set 13	set 14	set 15	set 16	set 17
6			measurement 1	49.93	58.01	53.67	54.72	52.82	54.86	52.42	56.29	57.00	54.91	54.16	52.22	54.77	55.43	53.98	54.96	54.45
7			measurement 2	54.82	55.37	54.85	56.16	54.17	53.29	55.89	54.85	54.93	53.71	55.36	56.19	56.20	54.97	53.61	52.66	55.22
8			measurement 3	52.86	54.03	51.88	54.23	55.55	56.00	55.58	55.07	54.94	55.67	58.68	53.64	55.92	57.09	53.74	54.20	58.44
9			measurement 4	58.41	54.55	57.69	55.85	54.40	55.89	56.89	54.85	53.21	53.89	53.58	56.99	55.64	57.37	54.43	52.43	54.31
10			measurement 5	54.88	58.59	54.30	55.96	55.74	53.78	58.22	52.65	52.29	54.02	54.72	55.00	52.55	55.73	56.79	52.93	52.24
11			measurement 6	51.94	53.61	54.01	55.77	55.19	56.19	54.97	53.31	56.57	56.57	54.04	52.37	54.96	53.51	54.01	55.49	55.11
12			measurement 7	54.97	51.62	56.14	54.25	54.04	58.01	56.99	54.35	56.91	53.43	58.54	53.14	55.06	54.44	56.67	55.34	55.13
13			measurement 8	57.53	55.17	55.75	53.30	54.25	54.14	53.86	54.67	56.72	54.78	56.52	52.54	54.74	57.28	54.53	57.05	56.07
14			measurement 9	52.73	53.31	53.58	55.74	55.01	51.88	54.88	54.30	50.97	57.53	52.60	53.55	51.10	56.12	54.51	54.48	55.92
15			measurement 10	56.74	54.48	57.44	52.62	53.93	57.10	54.64	54.29	52.48	54.47	53.73	55.93	54.56	57.20	51.21	54.57	58.45
16			measurement 11	55.84	53.28	57.30	54.89	55.84	54.25	53.11	56.56	57.57	54.61	52.79	55.79	59.69	56.08	57.51	50.79	53.52
17			measurement 12	52.11	48.22	56.17	55.15	50.15	53.73	57.08	51.88	56.08	49.66	56.55	52.96	51.45	58.31	52.58	53.30	54.74
18			measurement 13	56.82	53.76	53.40	56.72	52.61	55.76	55.72	58.52	52.21	52.41	52.38	51.64	52.88	54.66	54.63	53.16	55.62
19			measurement 14	58.51	50.70	57.53	48.97	57.38	56.44	56.27	60.33	52.87	53.96	50.25	54.56	53.85	53.68	54.85	52.61	54.48
20			measurement 15	51.40	51.69	53.56	53.86	52.79	59.27	51.11	54.38	56.14	55.93	52.61	52.33	53.28	55.48	55.42	54.37	55.24
21			measurement 16	54.66	57.63	56.23	54.81	53.78	57.19	54.72	57.28	52.95	55.07	55.21	55.51	57.83	54.60	55.81	57.03	53.63
22			measurement 17	57.94	52.32	53.74	55.34	51.96	55.67	59.60	57.33	53.54	54.17	59.58	54.79	58.73	53.68	56.90	54.58	58.82
23			measurement 18	56.40	53.36	52.74	56.45	54.11	55.40	52.78	52.45	57.18	55.79	54.75	54.37	58.36	56.67	55.11	56.10	54.11
24			measurement 19	56.31	56.28	55.38	52.01	58.61	55.68	53.18	55.49	49.93	54.80	56.88	53.35	57.02	52.19	53.96	55.61	57.45
25			measurement 20	54.52	57.40	52.04	52.81	56.61	54.78	55.86	57.73	54.71	54.76	56.21	53.52	57.73	51.80	55.44	56.78	53.28
26			measurement 21	54.84	55.09	49.81	52.16										55.29	59.24	58.09	57.09
27			measurement 22	50.77	54.14	53.66	54.05										54.01	57.20	54.69	53.82
28			measurement 23	57.65	55.20	53.55	55.04										56.50	52.47	55.69	54.07
29			measurement 24	57.35	54.57	57.41	55.08										56.36	58.73	53.13	52.51
30			measurement 25	56.96	54.31	55.14	53.87										57.25	53.26	57.31	55.43
31			Average of a set	55.08																
32			std dev of a set																	
33	Average of set averages																			
34	Average of set standard deviations																			
35	standard deviation of set averages																			
36																				
37																				

To copy the formula of cell D31to the cells on the right, move the mouse to the right-bottom corner of cell D31 until the mouse pointer changes into a cross as shown. Click, hold, and move the mouse right to cell AG31 then release the mouse.



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
1	L0	55.0																		
2	DeltaL	2.0																		
3	number of measurements per set	25																		
4	expected error in the average of a set	0.4																		
5				set 1	set 2	set 3	set 4	set 5	set 6	set 7	set 8	set 9	set 10	set 11	set 12	set 13	set 14	set 15	set 16	set 17
6			measurement 1	54.08	56.97	54.18	55.14	54.32	54.63	56.96	51.77	55.58	55.37	56.10	57.28	52.57	57.00	54.23	53.85	54.41
7			measurement 2	52.43	53.08	55.66	52.04	54.82	56.18	55.00	57.86	55.65	54.35	58.75	54.52	55.88	54.75	53.49	55.94	52.91
8			measurement 3	57.91	56.22	55.11	54.63	57.70	52.68	54.40	54.64	52.55	50.40	54.93	56.26	53.45	55.50	55.61	56.53	54.82
9			measurement 4	51.98	55.33	54.08	53.36	57.02	51.17	51.60	53.27	56.87	54.04	54.55	56.61	55.20	55.75	56.35	51.67	55.20
10			measurement 5	53.74	55.81	51.75	55.18	55.73	52.68	55.88	55.44	52.44	54.62	58.27	57.75	55.90	56.12	55.71	54.20	63.14
11			measurement 6	53.96	56.19	52.20	57.58	56.63	55.65	57.40	56.53	53.85	53.50	53.36	58.35	53.85	54.77	55.09	53.09	52.48
12			measurement 7	52.52	55.73	53.24	55.09	55.39	54.70	53.41	57.49	57.32	55.81	54.21	55.41	53.54	57.43	55.86	57.88	57.69
13			measurement 8	58.90	55.52	53.70	57.05	52.82	51.85	56.70	55.49	51.49	55.59	57.06	57.40	57.92	51.22	57.63	51.13	57.91
14			measurement 9	52.95	54.43	50.28	52.82	56.53	52.35	57.28	55.61	53.03	54.38	53.36	56.94	56.31	55.86	53.58	55.34	53.70
15			measurement 10	55.07	51.40	53.35	52.47	55.27	53.25	52.39	56.47	54.64	57.73	55.30	57.47	55.85	55.23	54.51	54.29	56.06
16			measurement 11	54.27	56.89	54.00	53.58	54.30	55.91	59.77	57.67	53.39	54.82	55.67	50.96	53.45	52.71	54.87	52.34	53.23
17			measurement 12	53.78	53.40	57.55	55.32	53.60	55.13	54.08	54.10	55.83	54.00	54.33	51.12	56.08	56.15	57.35	54.39	53.91
18			measurement 13	54.36	55.15	53.17	56.47	55.72	53.93	57.40	54.92	53.67	50.46	55.65	53.05	55.66	54.45	56.91	54.48	55.33
19			measurement 14	56.64	57.30	56.53	52.75	55.31	56.98	52.16	53.75	57.73	52.21	52.53	56.73	52.23	54.32	53.45	53.46	54.99
20			measurement 15	54.30	56.75	55.77	56.68	53.79	53.96	53.04	56.22	56.13	55.37	53.90	55.65	56.55	55.97	54.97	53.98	56.11
21			measurement 16	54.04	58.66	52.40	56.03	57.03	55.24	56.50	54.74	52.20	54.24	55.50	56.16	55.10	53.69	54.25	50.45	56.01
22			measurement 17	49.76	52.31	54.62	54.19	58.14	54.52	52.24	53.44	51.94	55.27	54.77	55.74	58.18	53.25	55.23	53.01	53.37
23			measurement 18	54.23	55.17	56.50	53.92	54.45	54.53	55.48	55.85	55.97	59.28	53.90	56.04	56.92	56.13	53.61	56.50	55.95
24			measurement 19	55.74	57.00	54.53	56.89	56.08	51.53	55.96	52.95	55.49	52.02	53.96	56.90	57.16	52.81	56.06	53.11	55.49
25			measurement 20	54.38	52.70	55.87	52.49	54.09	53.64	55.19	55.11	54.46	58.21	58.13	53.45	55.52	56.78	53.07	55.64	57.23
26			measurement 21	54.30	55.25	56.01	56.85	55.66	53.57	55.38	52.22	53.63	52.57	54.94	57.02	53.73	55.74	53.77	50.98	57.00
27			measurement 22	53.59	56.30	58.05	56.07	51.11	54.73	54.05	56.36	56.48	57.35	54.42	56.35	56.63	55.57	56.48	55.40	52.77
28			measurement 23	55.54	54.85	54.38	53.84	56.60	55.71	57.86	55.79	53.96	52.31	59.22	54.31	54.17	59.58	56.24	53.70	58.17
29			measurement 24	54.59	54.86	54.32	56.13	56.62	56.69	55.35	57.30	55.37	51.56	53.48	56.31	51.15	57.91	58.16	54.19	56.37
30			measurement 25	57.00	56.35	57.16	55.90	53.97	54.90	56.16	52.48	54.23	56.13	51.87	52.65	57.59	58.88	52.40	52.89	53.38
31			Average of a set	54.40	55.34	54.58	54.90	55.31	54.24	55.27	55.10	54.56	54.46	55.13	55.62	55.22	55.50	55.16	53.94	55.51
32			std dev of a set	=STDEV.S(D6:D30)																
33	Average of set averages																			
34	Average of set standard deviations																			
35	standard deviation of set averages																			
36																				
37																				

In cell D32, type the formula
=STDEV.S(D6:D30)
as shown, then press enter.

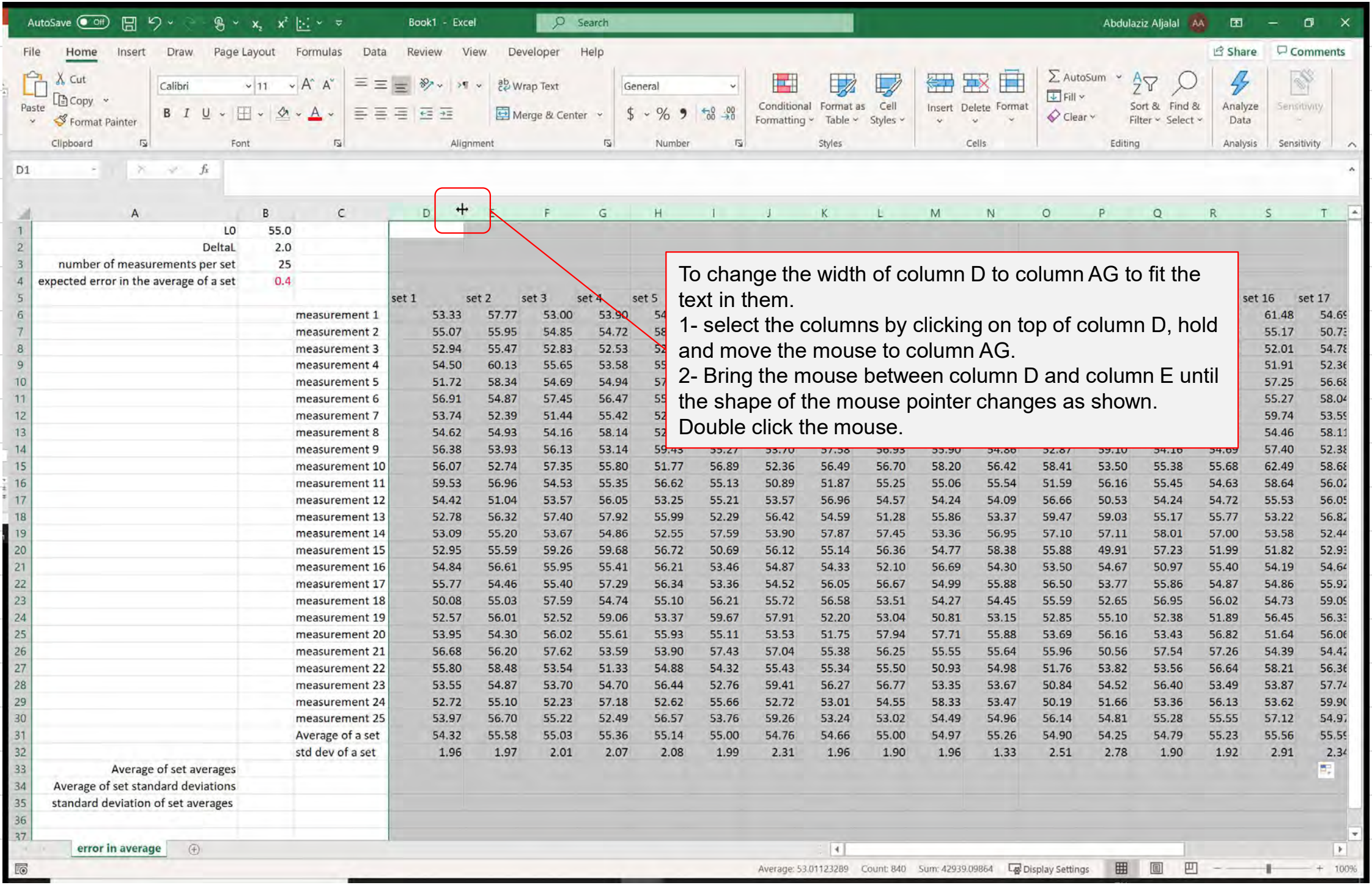


Book1 - Excel

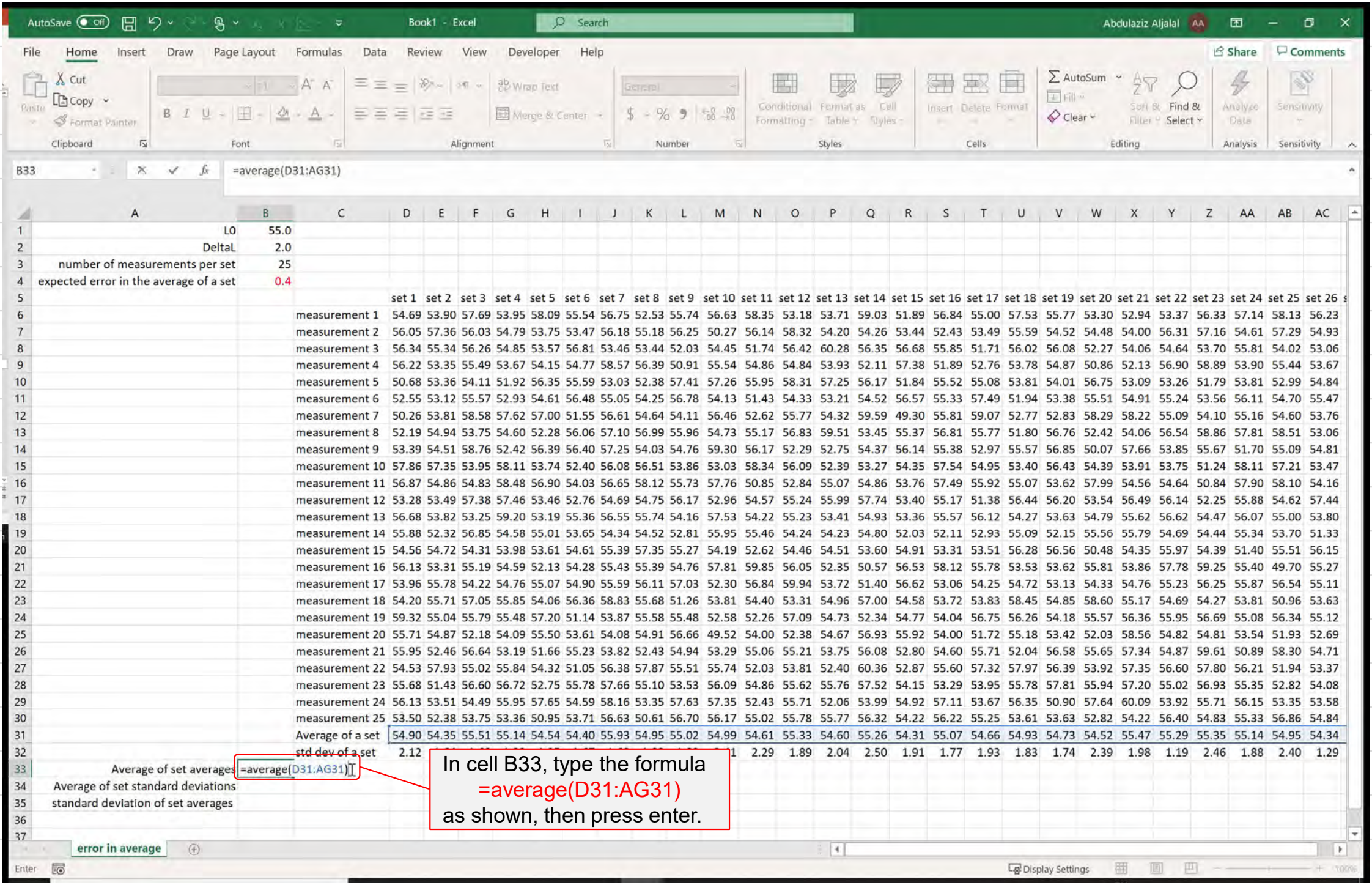
=STDEV.S(D6:D30)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
1	L0	55.0																		
2	DeltaL	2.0																		
3	number of measurements per set	25																		
4	expected error in the average of a set	0.4																		
5				set 1	set 2	set 3	set 4	set 5	set 6	set 7	set 8	set 9	set 10	set 11	set 12	set 13	set 14	set 15	set 16	set 17
6			measurement 1	56.95	56.59	56.55	54.38	54.80	50.00	56.07	55.71	54.41	53.02	54.72	54.58	56.68	53.92	56.14	57.31	56.52
7			measurement 2	55.71	58.17	54.26	54.53	56.21	49.86	57.03	55.03	56.73	54.08	58.44	55.28	55.20	56.58	55.18	51.59	58.22
8			measurement 3	55.41	54.93	53.92	57.86	51.72	52.14	55.71	54.66	51.92	55.84	51.87	53.92	54.97	55.24	56.90	56.96	54.40
9			measurement 4	51.91	58.42	54.22	57.60	51.68	53.40	57.08	53.72	52.92	53.55	55.14	53.84	54.53	56.45	52.06	52.00	56.31
10			measurement 5	56.55	55.47	56.88	55.79	56.00	57.88	56.18	54.70	53.76	54.20	53.97	53.22	55.36	55.47	56.01	52.83	57.74
11			measurement 6	58.98	50.64	52.14	58.70	55.71	57.78	52.61	55.18	54.11	54.46	56.75	54.24	53.31	53.31	55.46	56.42	55.98
12			measurement 7	52.85	56.40	55.22	51.84	53.57	53.88	55.18	56.69	54.44	54.97	55.99	58.92	56.92	49.99	53.37	54.27	54.79
13			measurement 8	56.26	57.56	55.80	53.23	56.67	56.48	54.35	55.87	56.26	57.62	54.90	53.00	54.92	54.93	52.98	55.73	53.65
14			measurement 9	51.50	54.05	53.86	53.75	57.89	56.52	51.62	53.19	55.04	57.14	56.97	56.56	54.65	52.97	58.64	53.51	55.54
15			measurement 10	57.67	58.41	56.51	55.99	55.15	52.79	54.53	57.74	50.74	56.47	58.57	54.74	56.05	56.67	51.64	53.82	54.97
16			measurement 11	53.22	54.48	54.69	55.35	56.32	51.58	57.01	55.20	51.74	54.12	55.19	57.07	55.08	54.46	60.02	52.44	53.39
17			measurement 12	54.97	56.55	53.68	51.87	55.41	53.24	51.68	57.47	55.51	57.16	54.73	56.46	57.23	51.41	55.24	55.74	53.43
18			measurement 13	53.99	55.80	56.36	53.21	58.02	54.94	56.23	54.70	49.68	54.65	56.18	55.01	56.37	52.92	56.04	57.03	58.89
19			measurement 14	51.90	52.12	57.30	53.88	54.77	53.84	52.76	52.00	53.09	54.94	54.60	57.32	52.08	54.58	56.73	57.72	53.41
20			measurement 15	55.00	58.17	53.05	56.58	53.36	54.52	53.93	52.38	57.59	57.97	52.45	58.81	55.45	54.48	54.96	50.95	55.56
21			measurement 16	53.09	55.23	56.05	54.97										53.22	56.88	58.34	53.45
22			measurement 17	52.81	55.80	52.97	58.71										55.47	56.30	59.24	57.34
23			measurement 18	56.91	54.29	53.04	58.16										54.94	54.07	56.34	54.42
24			measurement 19	52.77	58.64	55.64	58.38										54.65	52.74	53.89	54.37
25			measurement 20	53.46	55.40	53.60	52.60										55.77	55.86	57.53	51.10
26			measurement 21	54.45	54.23	54.00	54.20										54.73	58.94	53.58	55.15
27			measurement 22	54.24	53.99	55.76	53.99										53.95	56.85	56.18	57.16
28			measurement 23	54.85	60.81	51.39	54.77										57.03	53.54	59.59	54.05
29			measurement 24	54.39	55.33	54.39	55.44										59.05	56.20	55.63	59.84
30			measurement 25	58.54	56.94	56.13	58.08										55.48	58.01	57.18	53.68
31			Average of a set	54.74	55.94	54.70	55.35	55.05	53.98	55.00	55.10	53.64	54.96	55.32	55.79	54.87	54.71	55.63	55.43	55.33
32			std dev of a set	2.07																
33	Average of set averages																			
34	Average of set standard deviations																			
35	standard deviation of set averages																			
36																				
37																				

To copy the formula of cell D32 to the cells on the right, move the mouse to the right-bottom corner of cell D31 until the mouse pointer changes into a cross as shown. Click, hold, and move the mouse right to cell AG32 then release the mouse.

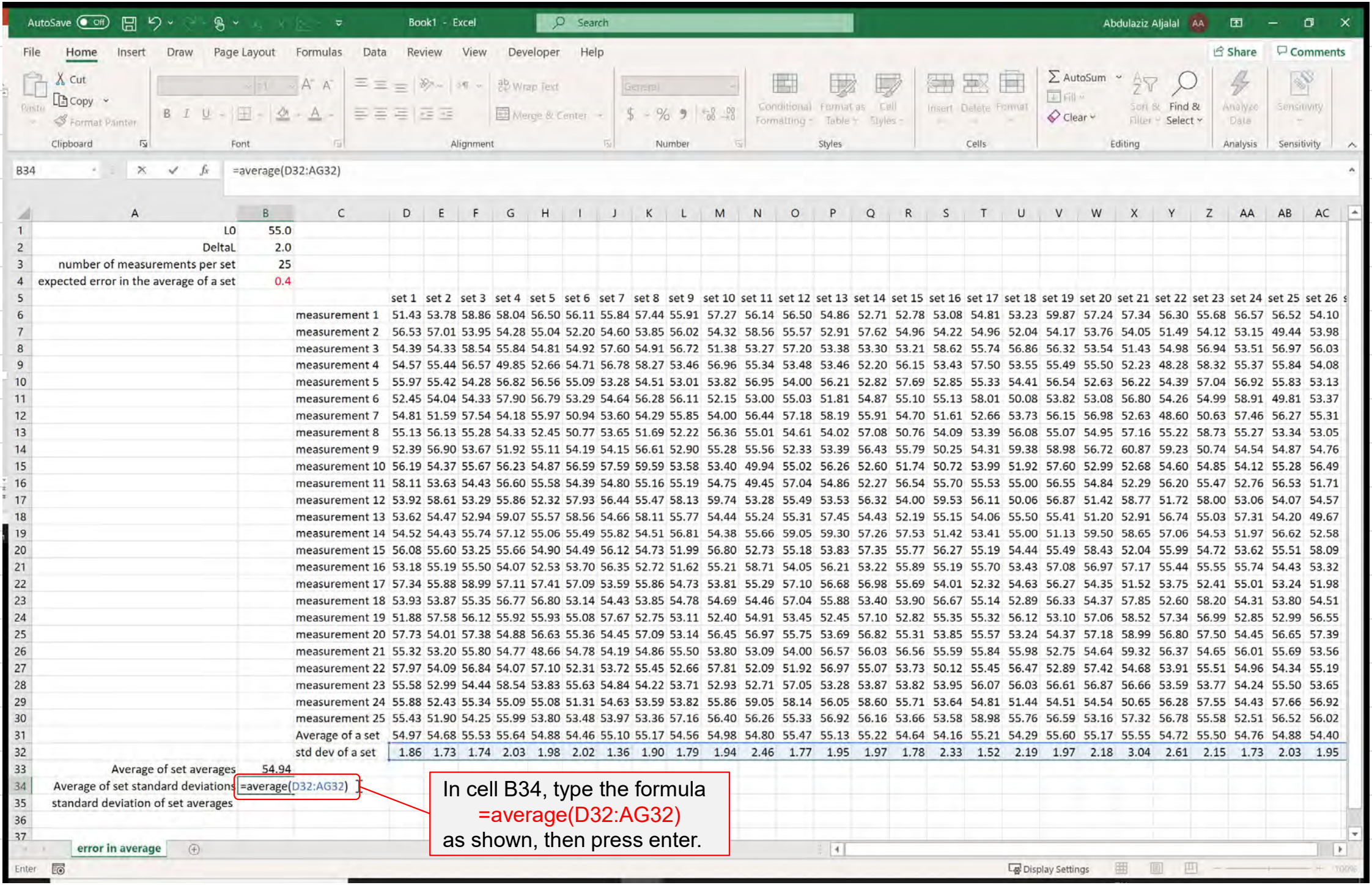


	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
1	L0	55.0																		
2	DeltaL	2.0																		
3	number of measurements per set	25																		
4	expected error in the average of a set	0.4																		
5				set 1		set 2	set 3	set 4	set 5										set 16	set 17
6			measurement 1		53.33	57.77	53.00	53.90	54										61.48	54.69
7			measurement 2		55.07	55.95	54.85	54.72	58										55.17	50.73
8			measurement 3		52.94	55.47	52.83	52.53	52										52.01	54.78
9			measurement 4		54.50	60.13	55.65	53.58	55										51.91	52.36
10			measurement 5		51.72	58.34	54.69	54.94	57										57.25	56.68
11			measurement 6		56.91	54.87	57.45	56.47	55										55.27	58.04
12			measurement 7		53.74	52.39	51.44	55.42	52										59.74	53.59
13			measurement 8		54.62	54.93	54.16	58.14	52										54.46	58.11
14			measurement 9		56.38	53.93	56.13	53.14	59.43	55.27	53.70	57.58	56.93	55.90	54.86	52.87	59.10	54.16	57.40	52.38
15			measurement 10		56.07	52.74	57.35	55.80	51.77	56.89	52.36	56.49	56.70	58.20	56.42	58.41	53.50	55.38	55.68	62.49	58.68
16			measurement 11		59.53	56.96	54.53	55.35	56.62	55.13	50.89	51.87	55.25	55.06	55.54	51.59	56.16	55.45	54.63	58.64	56.02
17			measurement 12		54.42	51.04	53.57	56.05	53.25	55.21	53.57	56.96	54.57	54.24	54.09	56.66	50.53	54.24	54.72	55.53	56.05
18			measurement 13		52.78	56.32	57.40	57.92	55.99	52.29	56.42	54.59	51.28	55.86	53.37	59.47	59.03	55.17	55.77	53.22	56.82
19			measurement 14		53.09	55.20	53.67	54.86	52.55	57.59	53.90	57.87	57.45	53.36	56.95	57.10	57.11	58.01	57.00	53.58	52.44
20			measurement 15		52.95	55.59	59.26	59.68	56.72	50.69	56.12	55.14	56.36	54.77	58.38	55.88	49.91	57.23	51.99	51.82	52.93
21			measurement 16		54.84	56.61	55.95	55.41	56.21	53.46	54.87	54.33	52.10	56.69	54.30	53.50	54.67	50.97	55.40	54.19	54.64
22			measurement 17		55.77	54.46	55.40	57.29	56.34	53.36	54.52	56.05	56.67	54.99	55.88	56.50	53.77	55.86	54.87	54.86	55.92
23			measurement 18		50.08	55.03	57.59	54.74	55.10	56.21	55.72	56.58	53.51	54.27	54.45	55.59	52.65	56.95	56.02	54.73	59.09
24			measurement 19		52.57	56.01	52.52	59.06	53.37	59.67	57.91	52.20	53.04	50.81	53.15	52.85	55.10	52.38	51.89	56.45	56.33
25			measurement 20		53.95	54.30	56.02	55.61	55.93	55.11	53.53	51.75	57.94	57.71	55.88	53.69	56.16	53.43	56.82	51.64	56.06
26			measurement 21		56.68	56.20	57.62	53.59	53.90	57.43	57.04	55.38	56.25	55.55	55.64	55.96	50.56	57.54	57.26	54.39	54.42
27			measurement 22		55.80	58.48	53.54	51.33	54.88	54.32	55.43	55.34	55.50	50.93	54.98	51.76	53.82	53.56	56.64	58.21	56.36
28			measurement 23		53.55	54.87	53.70	54.70	56.44	52.76	59.41	56.27	56.77	53.35	53.67	50.84	54.52	56.40	53.49	53.87	57.74
29			measurement 24		52.72	55.10	52.23	57.18	52.62	55.66	52.72	53.01	54.55	58.33	53.47	50.19	51.66	53.36	56.13	53.62	59.90
30			measurement 25		53.97	56.70	55.22	52.49	56.57	53.76	59.26	53.24	53.02	54.49	54.96	56.14	54.81	55.28	55.55	57.12	54.97
31			Average of a set		54.32	55.58	55.03	55.36	55.14	55.00	54.76	54.66	55.00	54.97	55.26	54.90	54.25	54.79	55.23	55.56	55.59
32			std dev of a set		1.96	1.97	2.01	2.07	2.08	1.99	2.31	1.96	1.90	1.96	1.33	2.51	2.78	1.90	1.92	2.91	2.34
33	Average of set averages																			
34	Average of set standard deviations																			
35	standard deviation of set averages																			
36																				
37																				

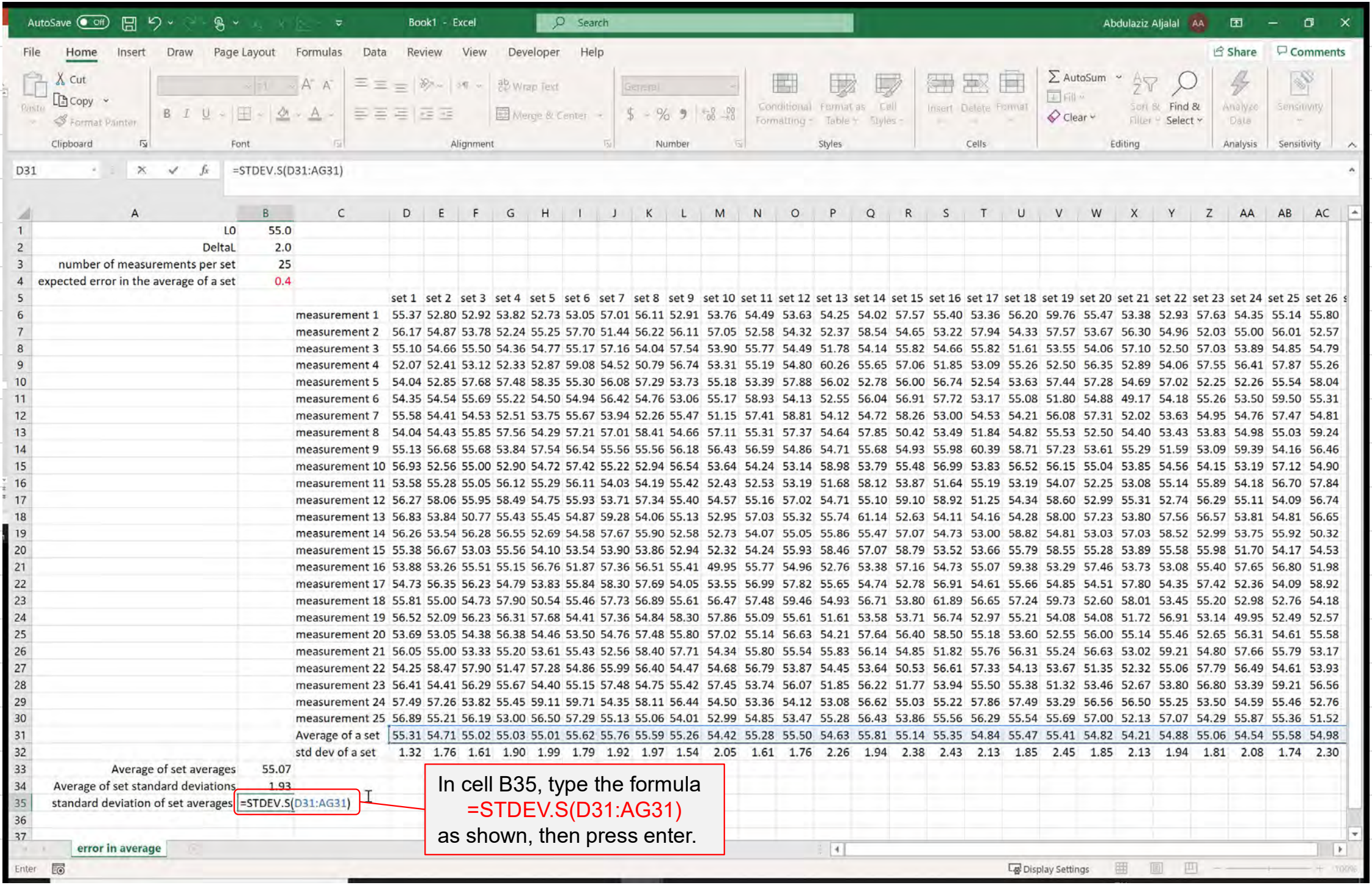


	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC
1	L0	55.0																											
2	DeltaL	2.0																											
3	number of measurements per set	25																											
4	expected error in the average of a set	0.4																											
5				set 1	set 2	set 3	set 4	set 5	set 6	set 7	set 8	set 9	set 10	set 11	set 12	set 13	set 14	set 15	set 16	set 17	set 18	set 19	set 20	set 21	set 22	set 23	set 24	set 25	set 26	s
6			measurement 1	54.69	53.90	57.69	53.95	58.09	55.54	56.75	52.53	55.74	56.63	58.35	53.18	53.71	59.03	51.89	56.84	55.00	57.53	55.77	53.30	52.94	53.37	56.33	57.14	58.13	56.23	
7			measurement 2	56.05	57.36	56.03	54.79	53.75	53.47	56.18	55.18	56.25	50.27	56.14	58.32	54.20	54.26	53.44	52.43	53.49	55.59	54.52	54.48	54.00	56.31	57.16	54.61	57.29	54.93	
8			measurement 3	56.34	55.34	56.26	54.85	53.57	56.81	53.46	53.44	52.03	54.45	51.74	56.42	60.28	56.35	56.68	55.85	51.71	56.02	56.08	52.27	54.06	54.64	53.70	55.81	54.02	53.06	
9			measurement 4	56.22	53.35	55.49	53.67	54.15	54.77	58.57	56.39	50.91	55.54	54.86	54.84	53.93	52.11	57.38	51.89	52.76	53.78	54.87	50.86	52.13	56.90	58.89	53.90	55.44	53.67	
10			measurement 5	50.68	53.36	54.11	51.92	56.35	55.59	53.03	52.38	57.41	57.26	55.95	58.31	57.25	56.17	51.84	55.52	55.08	53.81	54.01	56.75	53.09	53.26	51.79	53.81	52.99	54.84	
11			measurement 6	52.55	53.12	55.57	52.93	54.61	56.48	55.05	54.25	56.78	54.13	51.43	54.33	53.21	54.52	56.57	55.33	57.49	51.94	53.38	55.51	54.91	55.24	53.56	56.11	54.70	55.47	
12			measurement 7	50.26	53.81	58.58	57.62	57.00	51.55	56.61	54.64	54.11	56.46	52.62	55.77	54.32	59.59	49.30	55.81	59.07	52.77	52.83	58.29	58.22	55.09	54.10	55.16	54.60	53.76	
13			measurement 8	52.19	54.94	53.75	54.60	52.28	56.06	57.10	56.99	55.96	54.73	55.17	56.83	59.51	53.45	55.37	56.81	55.77	51.80	56.76	52.42	54.06	56.54	58.86	57.81	58.51	53.06	
14			measurement 9	53.39	54.51	58.76	52.42	56.39	56.40	57.25	54.03	54.76	59.30	56.17	52.29	52.75	54.37	56.14	55.38	52.97	55.57	56.85	50.07	57.66	53.85	55.67	51.70	55.09	54.81	
15			measurement 10	57.86	57.35	53.95	58.11	53.74	52.40	56.08	56.51	53.86	53.03	58.34	56.09	52.39	53.27	54.35	57.54	54.95	53.40	56.43	54.39	53.91	53.75	51.24	58.11	57.21	53.47	
16			measurement 11	56.87	54.86	54.83	58.48	56.90	54.03	56.65	58.12	55.73	57.76	50.85	52.84	55.07	54.86	53.76	57.49	55.92	55.07	53.62	57.99	54.56	54.64	50.84	57.90	58.10	54.16	
17			measurement 12	53.28	53.49	57.38	57.46	53.46	52.76	54.69	54.75	56.17	52.96	54.57	55.24	55.99	57.74	53.40	55.17	51.38	56.44	56.20	53.54	56.49	56.14	52.25	55.88	54.62	57.44	
18			measurement 13	56.68	53.82	53.25	59.20	53.19	55.36	56.55	55.74	54.16	57.53	54.22	55.23	53.41	54.93	53.36	55.57	56.12	54.27	53.63	54.79	55.62	56.62	54.47	56.07	55.00	53.80	
19			measurement 14	55.88	52.32	56.85	54.58	55.01	53.65	54.34	54.52	52.81	55.95	55.46	54.24	54.23	54.80	52.03	52.11	52.93	55.09	52.15	55.56	55.79	54.69	54.44	55.34	53.70	51.33	
20			measurement 15	54.56	54.72	54.31	53.98	53.61	54.61	55.39	57.35	55.27	54.19	52.62	54.46	54.51	53.60	54.91	53.31	53.51	56.28	56.56	50.48	54.35	55.97	54.39	51.40	55.51	56.15	
21			measurement 16	56.13	53.31	55.19	54.59	52.13	54.28	55.43	55.39	54.76	57.81	59.85	56.05	52.35	50.57	56.53	58.12	55.78	53.53	53.62	55.81	53.86	57.78	59.25	55.40	49.70	55.27	
22			measurement 17	53.96	55.78	54.22	54.76	55.07	54.90	55.59	56.11	57.03	52.30	56.84	59.94	53.72	51.40	56.62	53.06	54.25	54.72	53.13	54.33	54.76	55.23	56.25	55.87	56.54	55.11	
23			measurement 18	54.20	55.71	57.05	55.85	54.06	56.36	58.83	55.68	51.26	53.81	54.40	53.31	54.96	57.00	54.58	53.72	53.83	58.45	54.85	58.60	55.17	54.69	54.27	53.81	50.96	53.63	
24			measurement 19	59.32	55.04	55.79	55.48	57.20	51.14	53.87	55.58	55.48	52.58	52.26	57.09	54.73	52.34	54.77	54.04	56.75	56.26	54.18	55.57	56.36	55.95	56.69	55.08	56.34	55.12	
25			measurement 20	55.71	54.87	52.18	54.09	55.50	53.61	54.08	54.91	56.66	49.52	54.00	52.38	54.67	56.93	55.92	54.00	51.72	55.18	53.42	52.03	58.56	54.82	54.81	53.54	51.93	52.69	
26			measurement 21	55.95	52.46	56.64	53.19	51.66	55.23	53.82	52.43	54.94	53.29	55.06	55.21	53.75	56.08	52.80	54.60	55.71	52.04	56.58	55.65	57.34	54.87	59.61	50.89	58.30	54.71	
27			measurement 22	54.53	57.93	55.02	55.84	54.32	51.05	56.38	57.87	55.51	55.74	52.03	53.81	52.40	60.36	52.87	55.60	57.32	57.97	56.39	53.92	57.35	56.60	57.80	56.21	51.94	53.37	
28			measurement 23	55.68	51.43	56.60	56.72	52.75	55.78	57.66	55.10	53.53	56.09	54.86	55.62	55.76	57.52	54.15	53.29	53.95	55.78	57.81	55.94	57.20	55.02	56.93	55.35	52.82	54.08	
29			measurement 24	56.13	53.51	54.49	55.95	57.65	54.59	58.16	53.35	57.63	57.35	52.43	55.71	52.06	53.99	54.92	57.11	53.67	56.35	50.90	57.64	60.09	53.92	55.71	56.15	53.35	53.58	
30			measurement 25	53.50	52.38	53.75	53.36	50.95	53.71	56.63	50.61	56.70	56.17	55.02	55.78	55.77	56.32	54.22	56.22	55.25	53.61	53.63	52.82	54.22	56.40	54.83	55.33	56.86	54.84	
31			Average of a set	54.90	54.35	55.51	55.14	54.54	54.40	55.93	54.95	55.02	54.99	54.61	55.33	54.60	55.26	54.31	55.07	54.66	54.93	54.73	54.52	55.47	55.29	55.35	55.14	54.95	54.34	
32			std dev of a set	2.12											2.29	1.89	2.04	2.50	1.91	1.77	1.93	1.83	1.74	2.39	1.98	1.19	2.46	1.88	2.40	1.29	
33	Average of set averages	=average(D31:AG31)																											
34	Average of set standard deviations																												
35	standard deviation of set averages																												
36																													
37																													

In cell B33, type the formula
=average(D31:AG31)
as shown, then press enter.



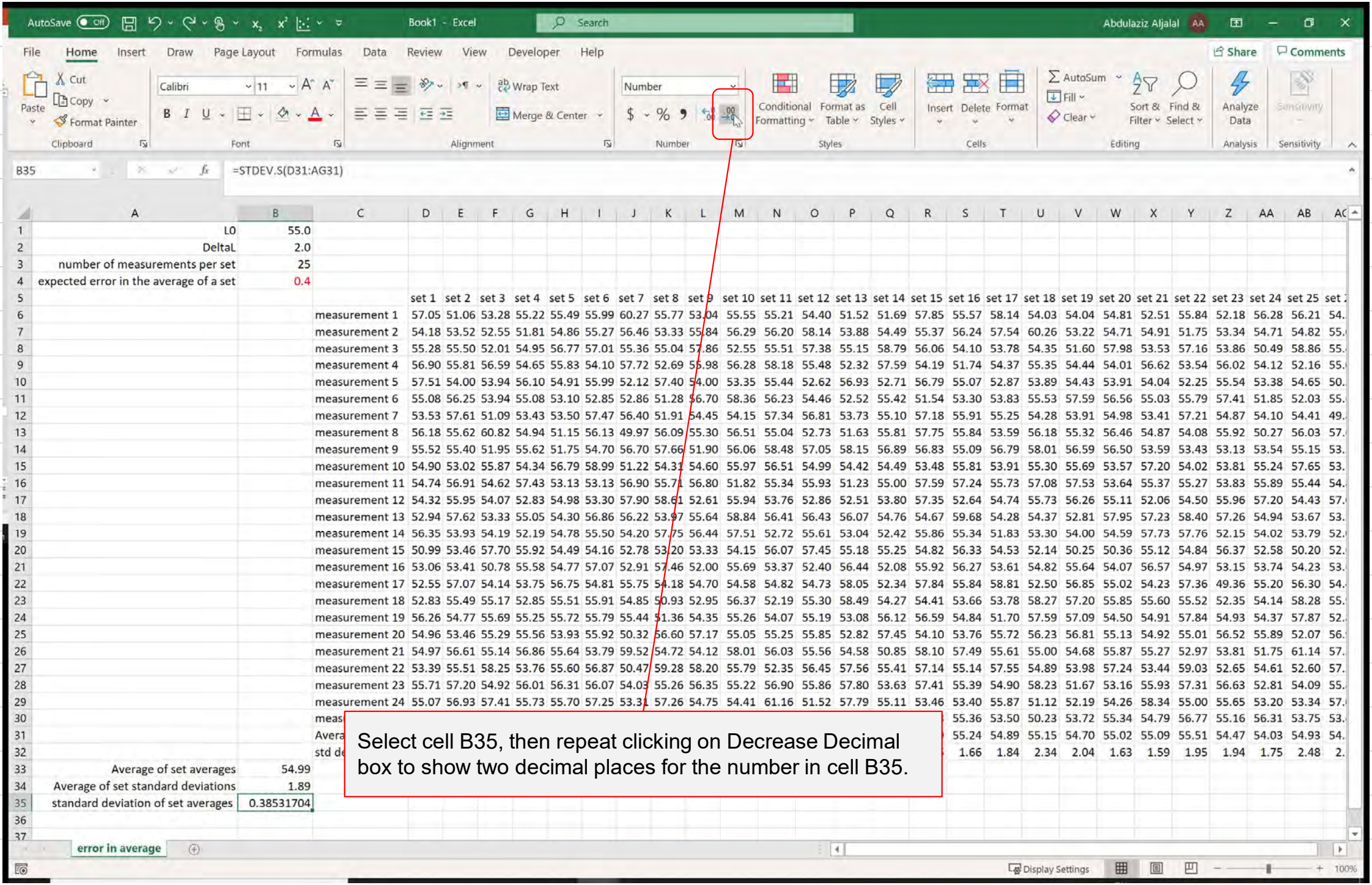
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC
1	L0	55.0																											
2	DeltaL	2.0																											
3	number of measurements per set	25																											
4	expected error in the average of a set	0.4																											
5				set 1	set 2	set 3	set 4	set 5	set 6	set 7	set 8	set 9	set 10	set 11	set 12	set 13	set 14	set 15	set 16	set 17	set 18	set 19	set 20	set 21	set 22	set 23	set 24	set 25	set 26	s
6			measurement 1	51.43	53.78	58.86	58.04	56.50	56.11	55.84	57.44	55.91	57.27	56.14	56.50	54.86	52.71	52.78	53.08	54.81	53.23	59.87	57.24	57.34	56.30	55.68	56.57	56.52	54.10	
7			measurement 2	56.53	57.01	53.95	54.28	55.04	52.20	54.60	53.85	56.02	54.32	58.56	55.57	52.91	57.62	54.96	54.22	54.96	52.04	54.17	53.76	54.05	51.49	54.12	53.15	49.44	53.98	
8			measurement 3	54.39	54.33	58.54	55.84	54.81	54.92	57.60	54.91	56.72	51.38	53.27	57.20	53.38	53.30	53.21	58.62	55.74	56.86	56.32	53.54	51.43	54.98	56.94	53.51	56.97	56.03	
9			measurement 4	54.57	55.44	56.57	49.85	52.66	54.71	56.78	58.27	53.46	56.96	55.34	53.48	53.46	52.20	56.15	53.43	57.50	53.55	55.49	55.50	52.23	48.28	58.32	55.37	55.84	54.08	
10			measurement 5	55.97	55.42	54.28	56.82	56.56	55.09	53.28	54.51	53.01	53.82	56.95	54.00	56.21	52.82	57.69	52.85	55.33	54.41	56.54	52.63	56.22	54.39	57.04	56.92	55.83	53.13	
11			measurement 6	52.45	54.04	54.33	57.90	56.79	53.29	54.64	56.28	56.11	52.15	53.00	55.03	51.81	54.87	55.10	55.13	58.01	50.08	53.82	53.08	56.80	54.26	54.99	58.91	49.81	53.37	
12			measurement 7	54.81	51.59	57.54	54.18	55.97	50.94	53.60	54.29	55.85	54.00	56.44	57.18	58.19	55.91	54.70	51.61	52.66	53.73	56.15	56.98	52.63	48.60	50.63	57.46	56.27	55.31	
13			measurement 8	55.13	56.13	55.28	54.33	52.45	50.77	53.65	51.69	52.22	56.36	55.01	54.61	54.02	57.08	50.76	54.09	53.39	56.08	55.07	54.95	57.16	55.22	58.73	55.27	53.34	53.05	
14			measurement 9	52.39	56.90	53.67	51.92	55.11	54.19	54.15	56.61	52.90	55.28	55.56	52.33	53.39	56.43	55.79	50.25	54.31	59.38	58.98	56.72	60.87	59.23	50.74	54.54	54.87	54.76	
15			measurement 10	56.19	54.37	55.67	56.23	54.87	56.59	57.59	59.59	53.58	53.40	49.94	55.02	56.26	52.60	51.74	50.72	53.99	51.92	57.60	52.99	52.68	54.60	54.85	54.12	55.28	56.49	
16			measurement 11	58.11	53.63	54.43	56.60	55.58	54.39	54.80	55.16	55.19	54.75	49.45	57.04	54.86	52.27	56.54	55.70	55.53	55.00	56.55	54.84	52.29	56.20	55.47	52.76	56.53	51.71	
17			measurement 12	53.92	58.61	53.29	55.86	52.32	57.93	56.44	55.47	58.13	59.74	53.28	55.49	53.53	56.32	54.00	59.53	56.11	50.06	56.87	51.42	58.77	51.72	58.00	53.06	54.07	54.57	
18			measurement 13	53.62	54.47	52.94	59.07	55.57	58.56	54.66	58.11	55.77	54.44	55.24	55.31	57.45	54.43	52.19	55.15	54.06	55.50	55.41	51.20	52.91	56.74	55.03	57.31	54.20	49.67	
19			measurement 14	54.52	54.43	55.74	57.12	55.06	55.49	55.82	54.51	56.81	54.38	55.66	59.05	59.30	57.26	57.53	51.42	53.41	55.00	51.13	59.50	58.65	57.06	54.53	51.97	56.62	52.58	
20			measurement 15	56.08	55.60	53.25	55.66	54.90	54.49	56.12	54.73	51.99	56.80	52.73	55.18	53.83	57.35	55.77	56.27	55.19	54.44	55.49	58.43	52.04	55.99	54.72	53.62	55.51	58.09	
21			measurement 16	53.18	55.19	55.50	54.07	52.53	53.70	56.35	52.72	51.62	55.21	58.71	54.05	56.21	53.22	55.89	55.19	55.70	53.43	57.08	56.97	57.17	55.44	55.55	55.74	54.43	53.32	
22			measurement 17	57.34	55.88	58.99	57.11	57.41	57.09	53.59	55.86	54.73	53.81	55.29	57.10	56.68	56.98	55.69	54.01	52.32	54.63	56.27	54.35	51.52	53.75	52.41	55.01	53.24	51.98	
23			measurement 18	53.93	53.87	55.35	56.77	56.80	53.14	54.43	53.85	54.78	54.69	54.46	57.04	55.88	53.40	53.90	56.67	55.14	52.89	56.33	54.37	57.85	52.60	58.20	54.31	53.80	54.51	
24			measurement 19	51.88	57.58	56.12	55.92	55.93	55.08	57.67	52.75	53.11	52.40	54.91	53.45	52.45	57.10	52.82	55.35	55.32	56.12	53.10	57.06	58.52	57.34	56.99	52.85	52.99	56.55	
25			measurement 20	57.73	54.01	57.38	54.88	56.63	55.36	54.45	57.09	53.14	56.45	56.97	55.75	53.69	56.82	55.31	53.85	55.57	53.24	54.37	57.18	58.99	56.80	57.50	54.45	56.65	57.39	
26			measurement 21	55.32	53.20	55.80	54.77	48.66	54.78	54.19	54.86	55.50	53.80	53.09	54.00	56.57	56.03	56.56	55.59	55.84	55.98	52.75	54.64	59.32	56.37	54.65	56.01	55.69	53.56	
27			measurement 22	57.97	54.09	56.84	54.07	57.10	52.31	53.72	55.45	52.66	57.81	52.09	51.92	56.97	55.07	53.73	50.12	55.45	56.47	52.89	57.42	54.68	53.91	55.51	54.96	54.34	55.19	
28			measurement 23	55.58	52.99	54.44	58.54	53.83	55.63	54.84	54.22	53.71	52.93	52.71	57.05	53.28	53.87	53.82	53.95	56.07	56.03	56.61	56.87	56.66	53.59	53.77	54.24	55.50	53.65	
29			measurement 24	55.88	52.43	55.34	55.09	55.08	51.31	54.63	53.59	53.82	55.86	59.05	58.14	56.05	58.60	55.71	53.64	54.81	51.44	54.51	54.54	50.65	56.28	57.55	54.43	57.66	56.92	
30			measurement 25	55.43	51.90	54.25	55.99	53.80	53.48	53.97	53.36	57.16	56.40	56.26	55.33	56.92	56.16	53.66	53.58	58.98	55.76	56.59	53.16	57.32	56.78	55.58	52.51	56.52	56.02	
31			Average of a set	54.97	54.68	55.53	55.64	54.88	54.46	55.10	55.17	54.56	54.98	54.80	55.47	55.13	55.22	54.64	54.16	55.21	54.29	55.60	55.17	55.55	54.72	55.50	54.76	54.88	54.40	
32			std dev of a set	1.86	1.73	1.74	2.03	1.98	2.02	1.36	1.90	1.79	1.94	2.46	1.77	1.95	1.97	1.78	2.33	1.52	2.19	1.97	2.18	3.04	2.61	2.15	1.73	2.03	1.95	
33	Average of set averages	54.94																											
34	Average of set standard deviations	=average(D32:AG32)																											
35	standard deviation of set averages																												
36																													
37																													



	A	B
1	L0	55.0
2	DeltaL	2.0
3	number of measurements per set	25
4	expected error in the average of a set	0.4
33	Average of set averages	55.07
34	Average of set standard deviations	1.93
35	standard deviation of set averages	=STDEV.S(D31:AG31)

	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC
5		set 1	set 2	set 3	set 4	set 5	set 6	set 7	set 8	set 9	set 10	set 11	set 12	set 13	set 14	set 15	set 16	set 17	set 18	set 19	set 20	set 21	set 22	set 23	set 24	set 25	set 26
6	measurement 1	55.37	52.80	52.92	53.82	52.73	53.05	57.01	56.11	52.91	53.76	54.49	53.63	54.25	54.02	57.57	55.40	53.36	56.20	59.76	55.47	53.38	52.93	57.63	54.35	55.14	55.80
7	measurement 2	56.17	54.87	53.78	52.24	55.25	57.70	51.44	56.22	56.11	57.05	52.58	54.32	52.37	58.54	54.65	53.22	57.94	54.33	57.57	53.67	56.30	54.96	52.03	55.00	56.01	52.57
8	measurement 3	55.10	54.66	55.50	54.36	54.77	55.17	57.16	54.04	57.54	53.90	55.77	54.49	51.78	54.14	55.82	54.66	55.82	51.61	53.55	54.06	57.10	52.50	57.03	53.89	54.85	54.79
9	measurement 4	52.07	52.41	53.12	52.33	52.87	59.08	54.52	50.79	56.74	53.31	55.19	54.80	60.26	55.65	57.06	51.85	53.09	55.26	52.50	56.35	52.89	54.06	57.55	56.41	57.87	55.26
10	measurement 5	54.04	52.85	57.68	57.48	58.35	55.30	56.08	57.29	53.73	55.18	53.39	57.88	56.02	52.78	56.00	56.74	52.54	53.63	57.44	57.28	54.69	57.02	52.25	52.26	55.54	58.04
11	measurement 6	54.35	54.54	55.69	55.22	54.50	54.94	56.42	54.76	53.06	55.17	58.93	54.13	52.55	56.04	56.91	57.72	53.17	55.08	51.80	54.88	49.17	54.18	55.26	53.50	59.50	55.31
12	measurement 7	55.58	54.41	54.53	52.51	53.75	55.67	53.94	52.26	55.47	51.15	57.41	58.81	54.12	54.72	58.26	53.00	54.53	54.21	56.08	57.31	52.02	53.63	54.95	54.76	57.47	54.81
13	measurement 8	54.04	54.43	55.85	57.56	54.29	57.21	57.01	58.41	54.66	57.11	55.31	57.37	54.64	57.85	50.42	53.49	51.84	54.82	55.53	52.50	54.40	53.43	53.83	54.98	55.03	59.24
14	measurement 9	55.13	56.68	55.68	53.84	57.54	56.54	55.56	55.56	56.18	56.43	56.59	54.86	54.71	55.68	54.93	55.98	60.39	58.71	57.23	53.61	55.29	51.59	53.09	59.39	54.16	56.46
15	measurement 10	56.93	52.56	55.00	52.90	54.72	57.42	55.22	52.94	56.54	53.64	54.24	53.14	58.98	53.79	55.48	56.99	53.83	56.52	56.15	55.04	53.85	54.56	54.15	53.19	57.12	54.90
16	measurement 11	53.58	55.28	55.05	56.12	55.29	56.11	54.03	54.19	55.42	52.43	52.53	53.19	51.68	58.12	53.87	51.64	55.19	53.19	54.07	52.25	53.08	55.14	55.89	54.18	56.70	57.84
17	measurement 12	56.27	58.06	55.95	58.49	54.75	55.93	53.71	57.34	55.40	54.57	55.16	57.02	54.71	55.10	59.10	58.92	51.25	54.34	58.60	52.99	55.31	52.74	56.29	55.11	54.09	56.74
18	measurement 13	56.83	53.84	50.77	55.43	55.45	54.87	59.28	54.06	55.13	52.95	57.03	55.32	55.74	61.14	52.63	54.11	54.16	54.28	58.00	57.23	53.80	57.56	56.57	53.81	54.81	56.65
19	measurement 14	56.26	53.54	56.28	56.55	52.69	54.58	57.67	55.90	52.58	52.73	54.07	55.05	55.86	55.47	57.07	54.73	53.00	58.82	54.81	53.03	57.03	58.52	52.99	53.75	55.92	50.32
20	measurement 15	55.38	56.67	53.03	55.56	54.10	53.54	53.90	53.86	52.94	52.32	54.24	55.93	58.46	57.07	58.79	53.52	53.66	55.79	58.55	55.28	53.89	55.58	55.98	51.70	54.17	54.53
21	measurement 16	53.88	53.26	55.51	55.15	56.76	51.87	57.36	56.51	55.41	49.95	55.77	54.96	52.76	53.38	57.16	54.73	55.07	59.38	53.29	57.46	53.73	53.08	55.40	57.65	56.80	51.98
22	measurement 17	54.73	56.35	56.23	54.79	53.83	55.84	58.30	57.69	54.05	53.55	56.99	57.82	55.65	54.74	52.78	56.91	54.61	55.66	54.85	54.51	57.80	54.35	57.42	52.36	54.09	58.92
23	measurement 18	55.81	55.00	54.73	57.90	50.54	55.46	57.73	56.89	55.61	56.47	57.48	59.46	54.93	56.71	53.80	61.89	56.65	57.24	59.73	52.60	58.01	53.45	55.20	52.98	52.76	54.18
24	measurement 19	56.52	52.09	56.23	56.31	57.68	54.41	57.36	54.84	58.30	57.86	55.09	55.61	51.61	53.58	53.71	56.74	52.97	55.21	54.08	54.08	51.72	56.91	53.14	49.95	52.49	52.57
25	measurement 20	53.69	53.05	54.38	56.38	54.46	53.50	54.76	57.48	55.80	57.02	55.14	56.63	54.21	57.64	56.40	58.50	55.18	53.60	52.55	56.00	55.14	55.46	52.65	56.31	54.61	55.58
26	measurement 21	56.05	55.00	53.33	55.20	53.61	55.43	52.56	58.40	57.71	54.34	55.80	55.54	55.83	56.14	54.85	51.82	55.76	56.31	55.24	56.63	53.02	59.21	54.80	57.66	55.79	53.17
27	measurement 22	54.25	58.47	57.90	51.47	57.28	54.86	55.99	56.40	54.47	54.68	56.79	53.87	54.45	53.64	50.53	56.61	57.33	54.13	53.67	51.35	52.32	55.06	57.79	56.49	54.61	53.93
28	measurement 23	56.41	54.41	56.29	55.67	54.40	55.15	57.48	54.75	55.42	57.45	53.74	56.07	51.85	56.22	51.77	53.94	55.50	55.38	51.32	53.46	52.67	53.80	56.80	53.39	59.21	56.56
29	measurement 24	57.49	57.26	53.82	55.45	59.11	59.71	54.35	58.11	56.44	54.50	53.36	54.12	53.08	56.62	55.03	55.22	57.86	57.49	53.29	56.56	56.50	55.25	53.50	54.59	55.46	52.76
30	measurement 25	56.89	55.21	56.19	53.00	56.50	57.29	55.13	55.06	54.01	52.99	54.85	53.47	55.28	56.43	53.86	55.56	56.29	55.54	55.69	57.00	52.13	57.07	54.29	55.87	55.36	51.52
31	Average of a set	55.31	54.71	55.02	55.03	55.01	55.62	55.76	55.59	55.26	54.42	55.28	55.50	54.63	55.81	55.14	55.35	54.84	55.47	55.41	54.82	54.21	54.88	55.06	54.54	55.58	54.98
32	std dev of a set	1.32	1.76	1.61	1.90	1.99	1.79	1.92	1.97	1.54	2.05	1.61	1.76	2.26	1.94	2.38	2.43	2.13	1.85	2.45	1.85	2.13	1.94	1.81	2.08	1.74	2.30

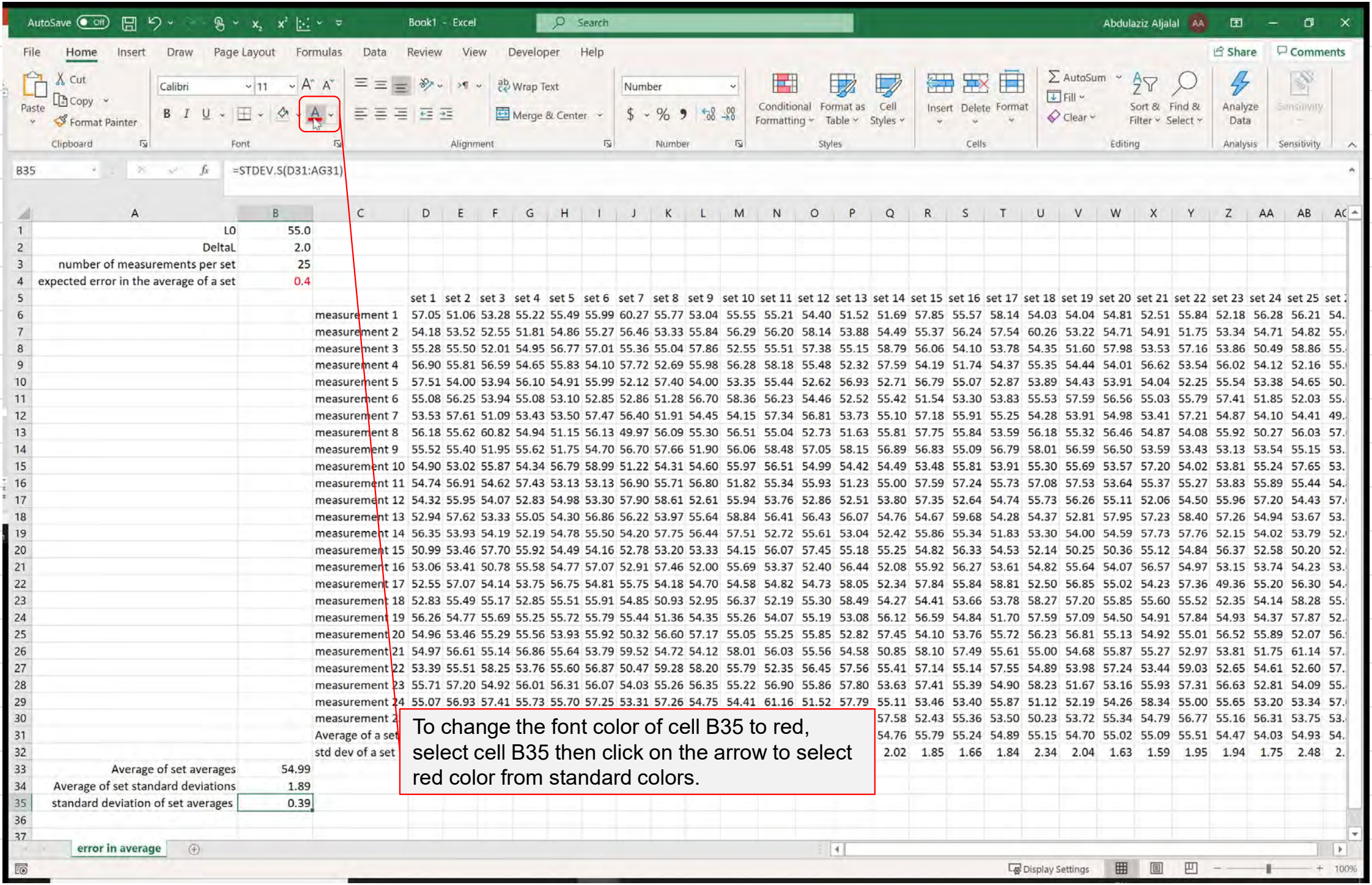
In cell B35, type the formula
=STDEV.S(D31:AG31)
as shown, then press enter.



	A	B
1	L0	55.0
2	DeltaL	2.0
3	number of measurements per set	25
4	expected error in the average of a set	0.4
33	Average of set averages	54.99
34	Average of set standard deviations	1.89
35	standard deviation of set averages	0.38531704

	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB
5		set 1	set 2	set 3	set 4	set 5	set 6	set 7	set 8	set 9	set 10	set 11	set 12	set 13	set 14	set 15	set 16	set 17	set 18	set 19	set 20	set 21	set 22	set 23	set 24	set 25
6	measurement 1	57.05	51.06	53.28	55.22	55.49	55.99	60.27	55.77	53.04	55.55	55.21	54.40	51.52	51.69	57.85	55.57	58.14	54.03	54.04	54.81	52.51	55.84	52.18	56.28	56.21
7	measurement 2	54.18	53.52	52.55	51.81	54.86	55.27	56.46	53.33	55.84	56.29	56.20	58.14	53.88	54.49	55.37	56.24	57.54	60.26	53.22	54.71	54.91	51.75	53.34	54.71	54.82
8	measurement 3	55.28	55.50	52.01	54.95	56.77	57.01	55.36	55.04	57.86	52.55	55.51	57.38	55.15	58.79	56.06	54.10	53.78	54.35	51.60	57.98	53.53	57.16	53.86	50.49	58.86
9	measurement 4	56.90	55.81	56.59	54.65	55.83	54.10	57.72	52.69	55.98	56.28	58.18	55.48	52.32	57.59	54.19	51.74	54.37	55.35	54.44	54.01	56.62	53.54	56.02	54.12	52.16
10	measurement 5	57.51	54.00	53.94	56.10	54.91	55.99	52.12	57.40	54.00	53.35	55.44	52.62	56.93	52.71	56.79	55.07	52.87	53.89	54.43	53.91	54.04	52.25	55.54	53.38	54.65
11	measurement 6	55.08	56.25	53.94	55.08	53.10	52.85	52.86	51.28	56.70	58.36	56.23	54.46	52.52	55.42	51.54	53.30	53.83	55.53	57.59	56.56	55.03	55.79	57.41	51.85	52.03
12	measurement 7	53.53	57.61	51.09	53.43	53.50	57.47	56.40	51.91	54.45	54.15	57.34	56.81	53.73	55.10	57.18	55.91	55.25	54.28	53.91	54.98	53.41	57.21	54.87	54.10	54.41
13	measurement 8	56.18	55.62	60.82	54.94	51.15	56.13	49.97	56.09	55.30	56.51	55.04	52.73	51.63	55.81	57.75	55.84	53.59	56.18	55.32	56.46	54.87	54.08	55.92	50.27	56.03
14	measurement 9	55.52	55.40	51.95	55.62	51.75	54.70	56.70	57.66	51.90	56.06	58.48	57.05	58.15	56.89	56.83	55.09	56.79	58.01	56.59	56.50	53.59	53.43	53.13	53.54	55.15
15	measurement 10	54.90	53.02	55.87	54.34	56.79	58.99	51.22	54.31	54.60	55.97	56.51	54.99	54.42	54.49	53.48	55.81	53.91	55.30	55.69	53.57	57.20	54.02	53.81	55.24	57.65
16	measurement 11	54.74	56.91	54.62	57.43	53.13	53.13	56.90	55.71	56.80	51.82	55.34	55.93	51.23	55.00	57.59	57.24	55.73	57.08	57.53	53.64	55.37	55.27	53.83	55.89	55.44
17	measurement 12	54.32	55.95	54.07	52.83	54.98	53.30	57.90	58.61	52.61	55.94	53.76	52.86	52.51	53.80	57.35	52.64	54.74	55.73	56.26	55.11	52.06	54.50	55.96	57.20	54.43
18	measurement 13	52.94	57.62	53.33	55.05	54.30	56.86	56.22	53.97	55.64	58.84	56.41	56.43	56.07	54.76	54.67	59.68	54.28	54.37	52.81	57.95	57.23	58.40	57.26	54.94	53.67
19	measurement 14	56.35	53.93	54.19	52.19	54.78	55.50	54.20	57.75	56.44	57.51	52.72	55.61	53.04	52.42	55.86	55.34	51.83	53.30	54.00	54.59	57.73	57.76	52.15	54.02	53.79
20	measurement 15	50.99	53.46	57.70	55.92	54.49	54.16	52.78	53.20	53.33	54.15	56.07	57.45	55.18	55.25	54.82	56.33	54.53	52.14	50.25	50.36	55.12	54.84	56.37	52.58	50.20
21	measurement 16	53.06	53.41	50.78	55.58	54.77	57.07	52.91	57.46	52.00	55.69	53.37	52.40	56.44	52.08	55.92	56.27	53.61	54.82	55.64	54.07	56.57	54.97	53.15	53.74	54.23
22	measurement 17	52.55	57.07	54.14	53.75	56.75	54.81	55.75	54.18	54.70	54.58	54.82	54.73	58.05	52.34	57.84	55.84	58.81	52.50	56.85	55.02	54.23	57.36	49.36	55.20	56.30
23	measurement 18	52.83	55.49	55.17	52.85	55.51	55.91	54.85	50.93	52.95	56.37	52.19	55.30	58.49	54.27	54.41	53.66	53.78	58.27	57.20	55.85	55.60	55.52	52.35	54.14	58.28
24	measurement 19	56.26	54.77	55.69	55.25	55.72	55.79	55.44	51.36	54.35	55.26	54.07	55.19	53.08	56.12	56.59	54.84	51.70	57.59	57.09	54.50	54.91	57.84	54.93	54.37	57.87
25	measurement 20	54.96	53.46	55.29	55.56	53.93	55.92	50.32	56.60	57.17	55.05	55.25	55.85	52.82	57.45	54.10	53.76	55.72	56.23	56.81	55.13	54.92	55.01	56.52	55.89	52.07
26	measurement 21	54.97	56.61	55.14	56.86	55.64	53.79	59.52	54.72	54.12	58.01	56.03	55.56	54.58	50.85	58.10	57.49	55.61	55.00	54.68	55.87	55.27	52.97	53.81	51.75	61.14
27	measurement 22	53.39	55.51	58.25	53.76	55.60	56.87	50.47	59.28	58.20	55.79	52.35	56.45	57.56	55.41	57.14	55.14	57.55	54.89	53.98	57.24	53.44	59.03	52.65	54.61	52.60
28	measurement 23	55.71	57.20	54.92	56.01	56.31	56.07	54.03	55.26	56.35	55.22	56.90	55.86	57.80	53.63	57.41	55.39	54.90	58.23	51.67	53.16	55.93	57.31	56.63	52.81	54.09
29	measurement 24	55.07	56.93	57.41	55.73	55.70	57.25	53.31	57.26	54.75	54.41	61.16	51.52	57.79	55.11	53.46	53.40	55.87	51.12	52.19	54.26	58.34	55.00	55.65	53.20	53.34
30	meas																55.36	53.50	50.23	53.72	55.34	54.79	56.77	55.16	56.31	53.75
31	Avera																55.24	54.89	55.15	54.70	55.02	55.09	55.51	54.47	54.03	54.93
32	std de																1.66	1.84	2.34	2.04	1.63	1.59	1.95	1.94	1.75	2.48

Select cell B35, then repeat clicking on Decrease Decimal box to show two decimal places for the number in cell B35.



AutoSave Off | Book1 - Excel | Search | Abdulaziz Aljalal

File Home Insert Draw Page Layout Formulas Data Review View Developer Help | Share | Comments

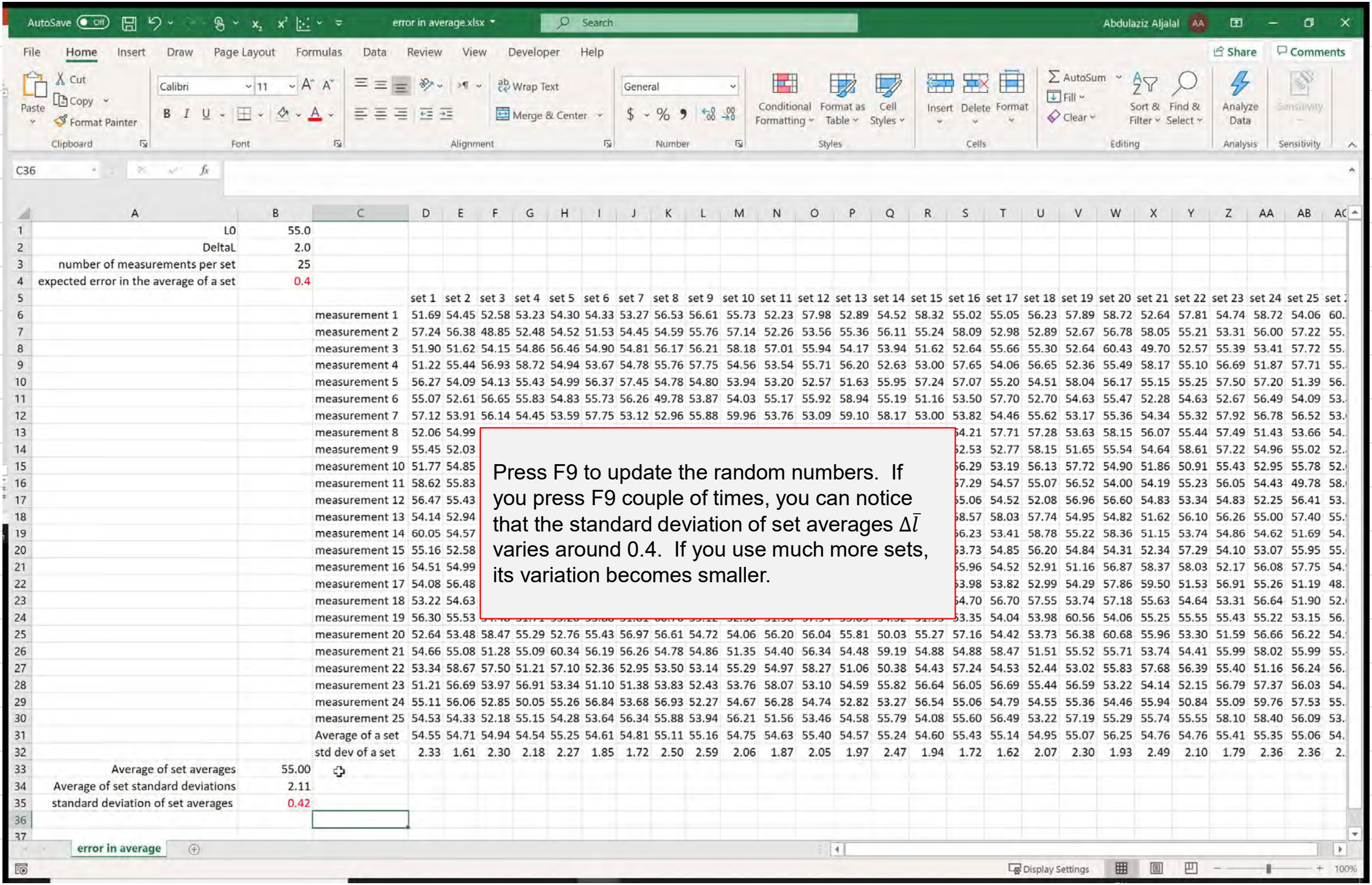
Paste | Cut | Copy | Format Painter | Clipboard | Calibri 11 | Font | Wrap Text | Merge & Center | Alignment | Number | Conditional Formatting | Format as Table | Cell Styles | Styles | Insert | Delete | Format | Cells | AutoSum | Fill | Clear | Sort & Filter | Find & Select | Editing | Analyze Data | Analysis | Sensitivity

B35 =STDEV.S(D31:AG31)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC
1	L0	55.0																											
2	DeltaL	2.0																											
3	number of measurements per set	25																											
4	expected error in the average of a set	0.4																											
5				set 1	set 2	set 3	set 4	set 5	set 6	set 7	set 8	set 9	set 10	set 11	set 12	set 13	set 14	set 15	set 16	set 17	set 18	set 19	set 20	set 21	set 22	set 23	set 24	set 25	set
6			measurement 1	57.05	51.06	53.28	55.22	55.49	55.99	60.27	55.77	53.04	55.55	55.21	54.40	51.52	51.69	57.85	55.57	58.14	54.03	54.04	54.81	52.51	55.84	52.18	56.28	56.21	54.
7			measurement 2	54.18	53.52	52.55	51.81	54.86	55.27	56.46	53.33	55.84	56.29	56.20	58.14	53.88	54.49	55.37	56.24	57.54	60.26	53.22	54.71	54.91	51.75	53.34	54.71	54.82	55.
8			measurement 3	55.28	55.50	52.01	54.95	56.77	57.01	55.36	55.04	57.86	52.55	55.51	57.38	55.15	58.79	56.06	54.10	53.78	54.35	51.60	57.98	53.53	57.16	53.86	50.49	58.86	55.
9			measurement 4	56.90	55.81	56.59	54.65	55.83	54.10	57.72	52.69	55.98	56.28	58.18	55.48	52.32	57.59	54.19	51.74	54.37	55.35	54.44	54.01	56.62	53.54	56.02	54.12	52.16	55.
10			measurement 5	57.51	54.00	53.94	56.10	54.91	55.99	52.12	57.40	54.00	53.35	55.44	52.62	56.93	52.71	56.79	55.07	52.87	53.89	54.43	53.91	54.04	52.25	55.54	53.38	54.65	50.
11			measurement 6	55.08	56.25	53.94	55.08	53.10	52.85	52.86	51.28	56.70	58.36	56.23	54.46	52.52	55.42	51.54	53.30	53.83	55.53	57.59	56.56	55.03	55.79	57.41	51.85	52.03	55.
12			measurement 7	53.53	57.61	51.09	53.43	53.50	57.47	56.40	51.91	54.45	54.15	57.34	56.81	53.73	55.10	57.18	55.91	55.25	54.28	53.91	54.98	53.41	57.21	54.87	54.10	54.41	49.
13			measurement 8	56.18	55.62	60.82	54.94	51.15	56.13	49.97	56.09	55.30	56.51	55.04	52.73	51.63	55.81	57.75	55.84	53.59	56.18	55.32	56.46	54.87	54.08	55.92	50.27	56.03	57.
14			measurement 9	55.52	55.40	51.95	55.62	51.75	54.70	56.70	57.66	51.90	56.06	58.48	57.05	58.15	56.89	56.83	55.09	56.79	58.01	56.59	56.50	53.59	53.43	53.13	53.54	55.15	53.
15			measurement 10	54.90	53.02	55.87	54.34	56.79	58.99	51.22	54.31	54.60	55.97	56.51	54.99	54.42	54.49	53.48	55.81	53.91	55.30	55.69	53.57	57.20	54.02	53.81	55.24	57.65	53.
16			measurement 11	54.74	56.91	54.62	57.43	53.13	53.13	56.90	55.71	56.80	51.82	55.34	55.93	51.23	55.00	57.59	57.24	55.73	57.08	57.53	53.64	55.37	55.27	53.83	55.89	55.44	54.
17			measurement 12	54.32	55.95	54.07	52.83	54.98	53.30	57.90	58.61	52.61	55.94	53.76	52.86	52.51	53.80	57.35	52.64	54.74	55.73	56.26	55.11	52.06	54.50	55.96	57.20	54.43	57.
18			measurement 13	52.94	57.62	53.33	55.05	54.30	56.86	56.22	53.97	55.64	58.84	56.41	56.43	56.07	54.76	54.67	59.68	54.28	54.37	52.81	57.95	57.23	58.40	57.26	54.94	53.67	53.
19			measurement 14	56.35	53.93	54.19	52.19	54.78	55.50	54.20	57.75	56.44	57.51	52.72	55.61	53.04	52.42	55.86	55.34	51.83	53.30	54.00	54.59	57.73	57.76	52.15	54.02	53.79	52.
20			measurement 15	50.99	53.46	57.70	55.92	54.49	54.16	52.78	53.20	53.33	54.15	56.07	57.45	55.18	55.25	54.82	56.33	54.53	52.14	50.25	50.36	55.12	54.84	56.37	52.58	50.20	52.
21			measurement 16	53.06	53.41	50.78	55.58	54.77	57.07	52.91	57.46	52.00	55.69	53.37	52.40	56.44	52.08	55.92	56.27	53.61	54.82	55.64	54.07	56.57	54.97	53.15	53.74	54.23	53.
22			measurement 17	52.55	57.07	54.14	53.75	56.75	54.81	55.75	54.18	54.70	54.58	54.82	54.73	58.05	52.34	57.84	55.84	58.81	52.50	56.85	55.02	54.23	57.36	49.36	55.20	56.30	54.
23			measurement 18	52.83	55.49	55.17	52.85	55.51	55.91	54.85	50.93	52.95	56.37	52.19	55.30	58.49	54.27	54.41	53.66	53.78	58.27	57.20	55.85	55.60	55.52	52.35	54.14	58.28	55.
24			measurement 19	56.26	54.77	55.69	55.25	55.72	55.79	55.44	51.36	54.35	55.26	54.07	55.19	53.08	56.12	56.59	54.84	51.70	57.59	57.09	54.50	54.91	57.84	54.93	54.37	57.87	52.
25			measurement 20	54.96	53.46	55.29	55.56	53.93	55.92	50.32	56.60	57.17	55.05	55.25	55.85	52.82	57.45	54.10	53.76	55.72	56.23	56.81	55.13	54.92	55.01	56.52	55.89	52.07	56.
26			measurement 21	54.97	56.61	55.14	56.86	55.64	53.79	59.52	54.72	54.12	58.01	56.03	55.56	54.58	50.85	58.10	57.49	55.61	55.00	54.68	55.87	55.27	52.97	53.81	51.75	61.14	57.
27			measurement 22	53.39	55.51	58.25	53.76	55.60	56.87	50.47	59.28	58.20	55.79	52.35	56.45	57.56	55.41	57.14	55.14	57.55	54.89	53.98	57.24	53.44	59.03	52.65	54.61	52.60	57.
28			measurement 23	55.71	57.20	54.92	56.01	56.31	56.07	54.03	55.26	56.35	55.22	56.90	55.86	57.80	53.63	57.41	55.39	54.90	58.23	51.67	53.16	55.93	57.31	56.63	52.81	54.09	55.
29			measurement 24	55.07	56.93	57.41	55.73	55.70	57.25	53.31	57.26	54.75	54.41	61.16	51.52	57.79	55.11	53.46	53.40	55.87	51.12	52.19	54.26	58.34	55.00	55.65	53.20	53.34	57.
30			measurement 2														57.58	52.43	55.36	53.50	50.23	53.72	55.34	54.79	56.77	55.16	56.31	53.75	53.
31			Average of a set														54.76	55.79	55.24	54.89	55.15	54.70	55.02	55.09	55.51	54.47	54.03	54.93	54.
32			std dev of a set														2.02	1.85	1.66	1.84	2.34	2.04	1.63	1.59	1.95	1.94	1.75	2.48	2.
33	Average of set averages	54.99																											
34	Average of set standard deviations	1.89																											
35	standard deviation of set averages	0.39																											
36																													
37																													

To change the font color of cell B35 to red, select cell B35 then click on the arrow to select red color from standard colors.

error in average | Display Settings | 100%



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC
1	L0	55.0																											
2	DeltaL	2.0																											
3	number of measurements per set	25																											
4	expected error in the average of a set	0.4																											
5				set 1	set 2	set 3	set 4	set 5	set 6	set 7	set 8	set 9	set 10	set 11	set 12	set 13	set 14	set 15	set 16	set 17	set 18	set 19	set 20	set 21	set 22	set 23	set 24	set 25	set
6			measurement 1	51.69	54.45	52.58	53.23	54.30	54.33	53.27	56.53	56.61	55.73	52.23	57.98	52.89	54.52	58.32	55.02	55.05	56.23	57.89	58.72	52.64	57.81	54.74	58.72	54.06	60.
7			measurement 2	57.24	56.38	48.85	52.48	54.52	51.53	54.45	54.59	55.76	57.14	52.26	53.56	55.36	56.11	55.24	58.09	52.98	52.89	52.67	56.78	58.05	55.21	53.31	56.00	57.22	55.
8			measurement 3	51.90	51.62	54.15	54.86	56.46	54.90	54.81	56.17	56.21	58.18	57.01	55.94	54.17	53.94	51.62	52.64	55.66	55.30	52.64	60.43	49.70	52.57	55.39	53.41	57.72	55.
9			measurement 4	51.22	55.44	56.93	58.72	54.94	53.67	54.78	55.76	57.75	54.56	53.54	55.71	56.20	52.63	53.00	57.65	54.06	56.65	52.36	55.49	58.17	55.10	56.69	51.87	57.71	55.
10			measurement 5	56.27	54.09	54.13	55.43	54.99	56.37	57.45	54.78	54.80	53.94	53.20	52.57	51.63	55.95	57.24	57.07	55.20	54.51	58.04	56.17	55.15	55.25	57.50	57.20	51.39	56.
11			measurement 6	55.07	52.61	56.65	55.83	54.83	55.73	56.26	49.78	53.87	54.03	55.17	55.92	58.94	55.19	51.16	53.50	57.70	52.70	54.63	55.47	52.28	54.63	52.67	56.49	54.09	53.
12			measurement 7	57.12	53.91	56.14	54.45	53.59	57.75	53.12	52.96	55.88	59.96	53.76	53.09	59.10	58.17	53.00	53.82	54.46	55.62	53.17	55.36	54.34	55.32	57.92	56.78	56.52	53.
13			measurement 8	52.06	54.99														54.21	57.71	57.28	53.63	58.15	56.07	55.44	57.49	51.43	53.66	54.
14			measurement 9	55.45	52.03														52.53	52.77	58.15	51.65	55.54	54.64	58.61	57.22	54.96	55.02	52.
15			measurement 10	51.77	54.85														56.29	53.19	56.13	57.72	54.90	51.86	50.91	55.43	52.95	55.78	52.
16			measurement 11	58.62	55.83														57.29	54.57	55.07	56.52	54.00	54.19	55.23	56.05	54.43	49.78	58.
17			measurement 12	56.47	55.43														55.06	54.52	52.08	56.96	56.60	54.83	53.34	54.83	52.25	56.41	53.
18			measurement 13	54.14	52.94														58.57	58.03	57.74	54.95	54.82	51.62	56.10	56.26	55.00	57.40	55.
19			measurement 14	60.05	54.57														56.23	53.41	58.78	55.22	58.36	51.15	53.74	54.86	54.62	51.69	54.
20			measurement 15	55.16	52.58														53.73	54.85	56.20	54.84	54.31	52.34	57.29	54.10	53.07	55.95	55.
21			measurement 16	54.51	54.99														55.96	54.52	52.91	51.16	56.87	58.37	58.03	52.17	56.08	57.75	54.
22			measurement 17	54.08	56.48														53.98	53.82	52.99	54.29	57.86	59.50	51.53	56.91	55.26	51.19	48.
23			measurement 18	53.22	54.63														54.70	56.70	57.55	53.74	57.18	55.63	54.64	53.31	56.64	51.90	52.
24			measurement 19	56.30	55.53														53.35	54.04	53.98	60.56	54.06	55.25	55.55	55.43	55.22	53.15	56.
25			measurement 20	52.64	53.48	58.47	55.29	52.76	55.43	56.97	56.61	54.72	54.06	56.20	56.04	55.81	50.03	55.27	57.16	54.42	53.73	56.38	60.68	55.96	53.30	51.59	56.66	56.22	54.
26			measurement 21	54.66	55.08	51.28	55.09	60.34	56.19	56.26	54.78	54.86	51.35	54.40	56.34	54.48	59.19	54.88	54.88	58.47	51.51	55.52	55.71	53.74	54.41	55.99	58.02	55.99	55.
27			measurement 22	53.34	58.67	57.50	51.21	57.10	52.36	52.95	53.50	53.14	55.29	54.97	58.27	51.06	50.38	54.43	57.24	54.53	52.44	53.02	55.83	57.68	56.39	55.40	51.16	56.24	56.
28			measurement 23	51.21	56.69	53.97	56.91	53.34	51.10	51.38	53.83	52.43	53.76	58.07	53.10	54.59	55.82	56.64	56.05	56.69	55.44	56.59	53.22	54.14	52.15	56.79	57.37	56.03	54.
29			measurement 24	55.11	56.06	52.85	50.05	55.26	56.84	53.68	56.93	52.27	54.67	56.28	54.74	52.82	53.27	56.54	55.06	54.79	54.55	55.36	54.46	55.94	50.84	55.09	59.76	57.53	55.
30			measurement 25	54.53	54.33	52.18	55.15	54.28	53.64	56.34	55.88	53.94	56.21	51.56	53.46	54.58	55.79	54.08	55.60	56.49	53.22	57.19	55.29	55.74	55.55	58.10	58.40	56.09	53.
31			Average of a set	54.55	54.71	54.94	54.54	55.25	54.61	54.81	55.11	55.16	54.75	54.63	55.40	54.57	55.24	54.60	55.43	55.14	54.95	55.07	56.25	54.76	54.76	55.41	55.35	55.06	54.
32			std dev of a set	2.33	1.61	2.30	2.18	2.27	1.85	1.72	2.50	2.59	2.06	1.87	2.05	1.97	2.47	1.94	1.72	1.62	2.07	2.30	1.93	2.49	2.10	1.79	2.36	2.36	2.
33	Average of set averages	55.00																											
34	Average of set standard deviations	2.11																											
35	standard deviation of set averages	0.42																											
36																													
37																													

Press F9 to update the random numbers. If you press F9 couple of times, you can notice that the standard deviation of set averages $\Delta\bar{l}$ varies around 0.4. If you use much more sets, its variation becomes smaller.