FACULTY OF ENGINEERING

DESIGN AND PRODUCTION ENGINEERING DEPARTMENT

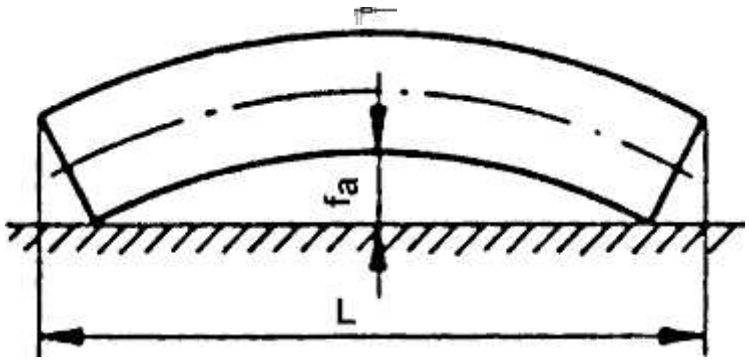
Engineering Metrology

Credit Hour System

Report On:

(1)

Out of ◌Straightness



Metrology laboratory

Student Name	Remark
Class No:	Signature
B.N.	

2016

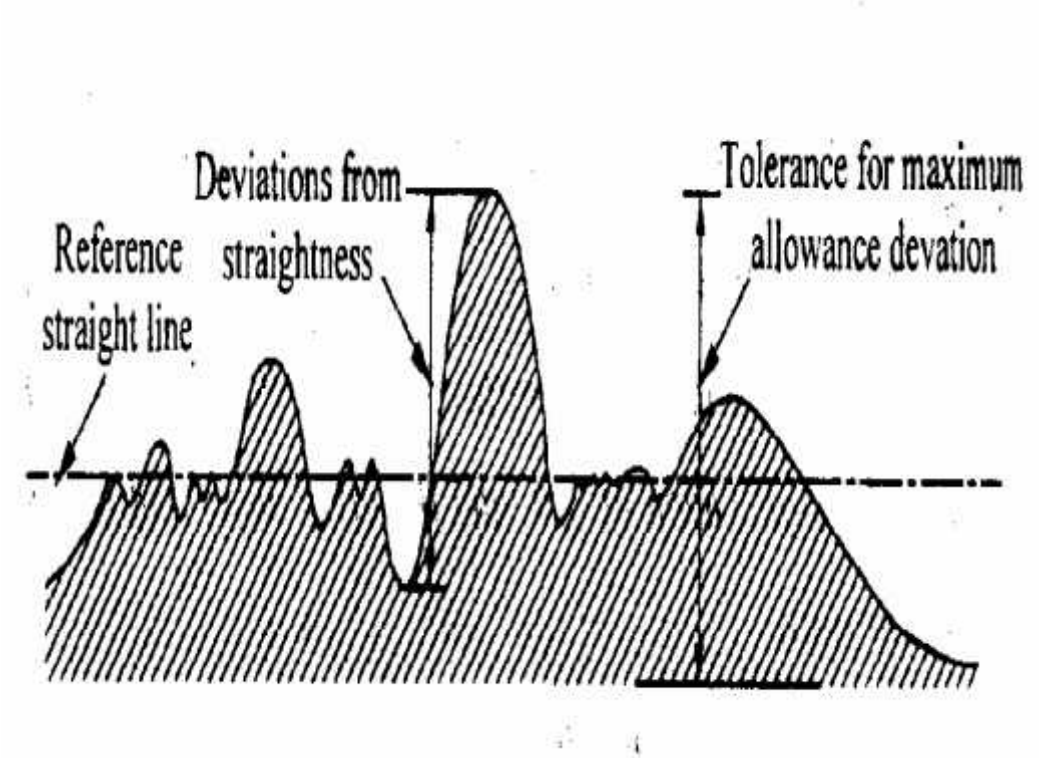
Definition:

The straightness tolerance of a line is the distance between two parallel planes between which all points on the line must lie if the tolerance is specified in only one direction.

Depending on the manufacturing process, three accuracy grades are differentiated.

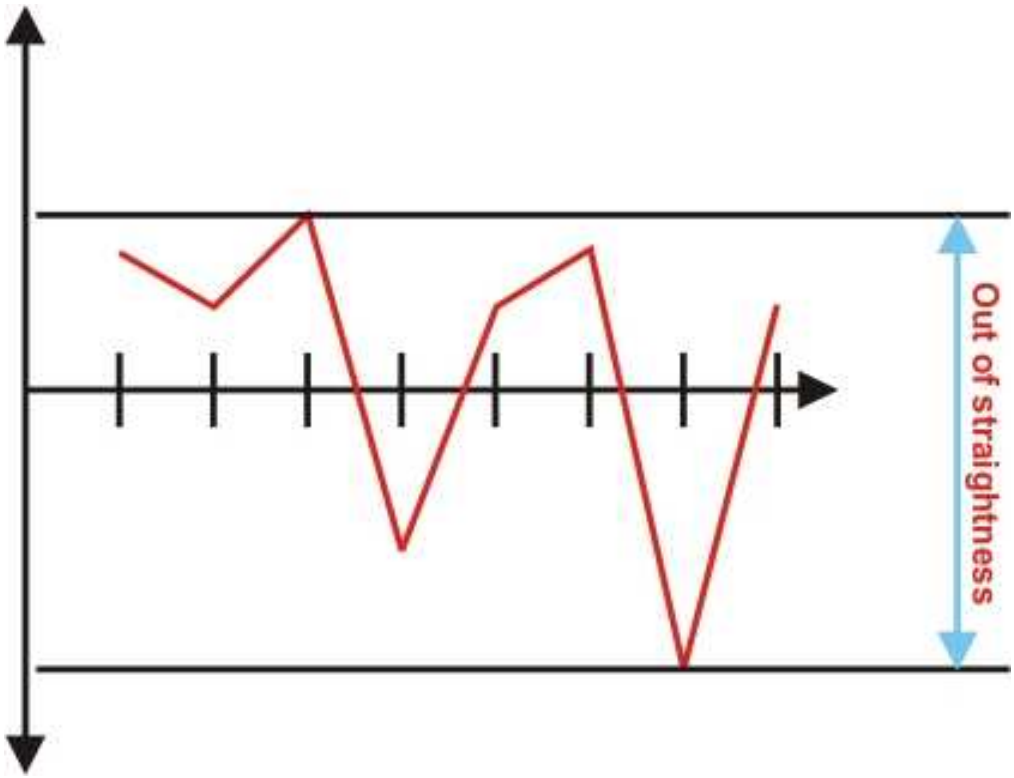
- Coarse (g) for tolerances that can be maintained by ceramic manufacturing techniques, for example, by extruding, casting or turning, which find use in high voltage electrical and chemical apparatus technologies.
- Medium(m) applies primarily to ceramic products of medium size produced by extruding, unmetered pressing, metered moist pressing, metered dry pressing or white finishing.
- Fine (f) applies to products for which the accuracy grades coarse and medium are inadequate. The fine grade can only be achieved using additional measures such as grinding after sintering. If the required accuracy is "fine", then the degree of accuracy must be agreed between the manufacturer and user.

The specification for general tolerances for straightness (B) of "medium" accuracy grade is: General tolerance DIN 40 680-B-m.



What is the meaning of out of straightness?

It is the difference between the maximum positive and the maximum negative value



Experiment

Objective:

The objective of this experiment is to determine the degree of out of straightness using different methods.

Equipments:

The equipments used in this experiments are:

- Straight edge
- Sensitive level
- Steel rule

Procedure:

1- Divide the straight edge into equal spaces according the level span (example: 100 mm). divide the length in to 10 parts

2- Put the straight edge on the slip gauge in the right position which maximize the moment of inertia (space = 0.554 length)

5-move the two slip gauge in steps along the surface to be checked.

6- At each position two readings were taken

7-repeat 5&6 times with the ganging of the slip gauge

9- Adjust all readings to relate to the first point.

10 – On reaching the last point, the level should be moved backwards over the same points to obtain reading checking.

11 – The mean of the two readings for each position should taken.

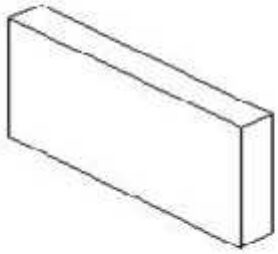
12 – The results are then adjusted to eliminate the error introduced due to both the position of supports and

the natural deflection of the surface. This can be done in tabular form .

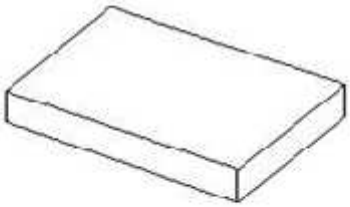
Right Positioning of straight edges:

Straight edge is a measuring tool which consists of a length of a steel of narrow and deep section.

For checking the straightness of any surface, the straight, edge is placed over the surface and two are viewed against the light, which clearly indicates the straightness



Right



Wrong

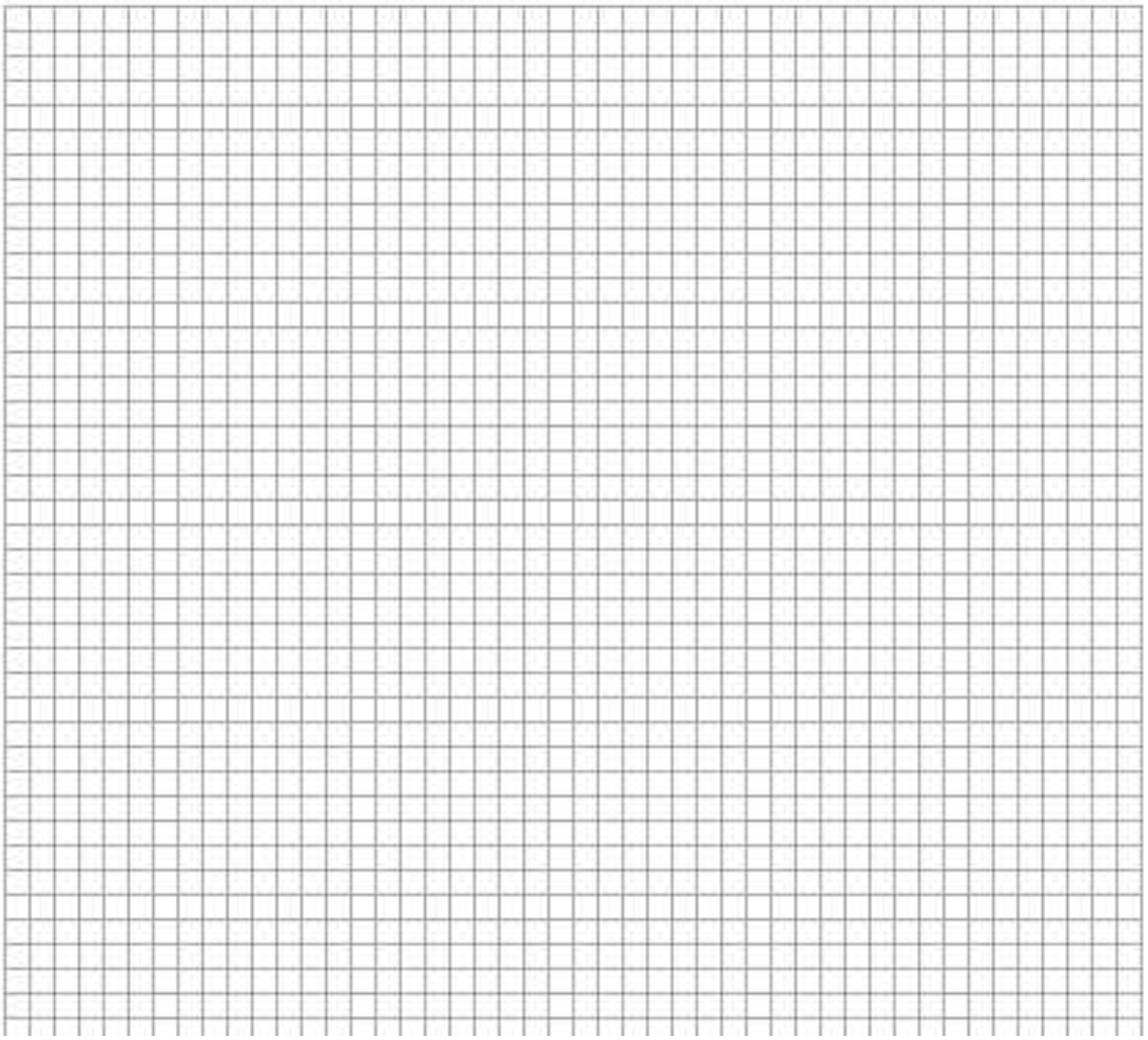
The first method “Inaccurate method “ the straight edge is placed over the surface and two are viewed against the light, which clearly indicates the straightness. Usually the gap between the straight edge and surface will be negligibly small for perfect straight surfaces.

It will depend on the intended use of the straight edge . the following formulas , having foreign standards (DIN) for source

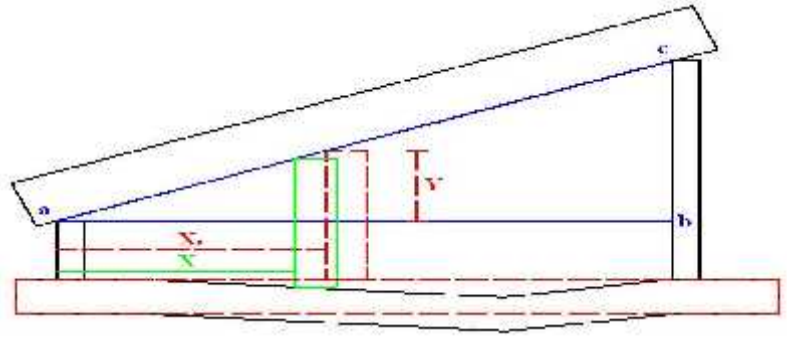
Tool Accuracy Grade	Maximum Deviation from Mean Plane of Any Point along Measuring Surface
Reference quality straight edge	$\pm\left(0.000{,}040+\frac{L}{200{,}000}\right)$ inches
Toolmaker quality straight edge	$\pm\left(0.000{,}080+\frac{L}{100{,}000}\right)$ inches

Readings

Position					
Readings					



Wedge Readings



Position					
Readings					

Measurement using level

Experiment Objective:

For a given Micrometer Clinometers it is required to:

- Use Micrometer Clinometers to check the straightness of the edge.
- Determine the maximum out-of-straightness using semi analytical method of analysis.

Measuring procedure

Forward Reading of Micrometer Clinometers:

- Put the Clinometers on two slip gauges and make the distance between them 10 cm
- Rotate the thimble till the two bubbles match
- Take the reading from main scale and from the thimble scale

Backward Reading of Micrometer Clinometers:

For the same measured distance (forward reading taken)

- Change the position of the two slip gauges to reveres direction
- Reverse the Clinometers
- Rotate the Thimble till the two bubbles matches
- Take the reading from main scale and from the thimble scale
- Use the following relation to get the height of the measured point related to the known one, it divided on 10 because the reading of Clinometers is adjusted as it sets on one meter base not 10 cm, so we divide the value on 10 to get the true height of the point:

$$height = (forward - backward) / 2 * 10$$

- Repeat these procedures for all points on the edge to be measured.
- Calculations: (Semi Analytical Method)

Length (cm)	Forward (mm)	Backward (mm)	Height (mm)	Cumulative
0 – 10	14.54	5.70	0.44	0.44
10 – 20	14.54	5.65	0.44	0.88
20 – 30	14.49	5.68	0.44	1.32

In columns 1, 2 & 3 ..... Readings I got

In 4th column:

height = (forward – backward) / 2 * 10

In 5th column:

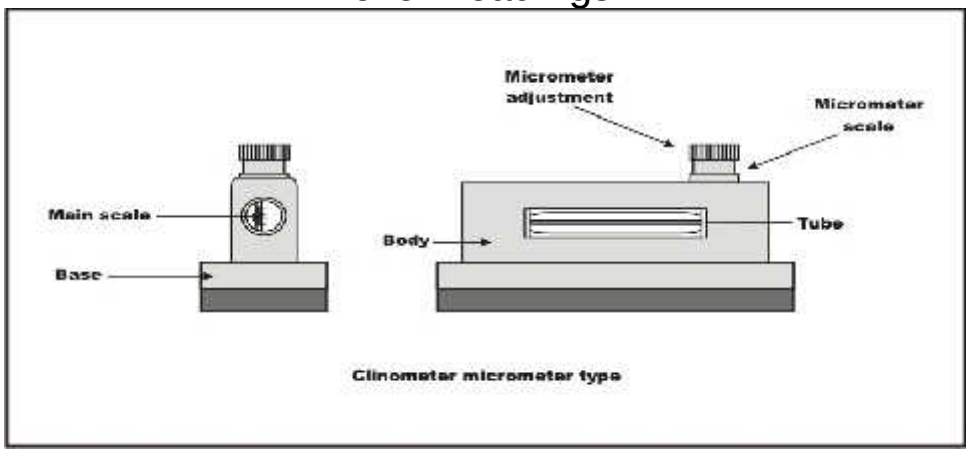
every number + the previous one till last reading

real reading =forward- backward/2

- Note :

The reading in the micrometer is mm/m so we have to convert it to mm so we will divide on 10 mm

Level Readings



Position					
Readings					

Experiment Analysis

A straight edge of rectangular cross section is checked using a precision spirit level which was marked

" 1 division = …….. mm in ……. mm.

The readings of the bubble in the forward and backward directions for the five positions taken along the edges as shown in the following table, readings are taken as divisions.

The interval distance is …….. mm.

	First	*Second*	*Third*	*Fourth*	*Fifth*
Forward					
Backward					

Step No. 1

Convert the reading from division to their corresponding mm values.

Scale value of the level = ……..

The reading were taken at …… mm interval

Thus each reading must be multiplied by ……. mm

	First	*Second*	*Third*	*Fourth*	*Fifth*
Forward					
Backward					

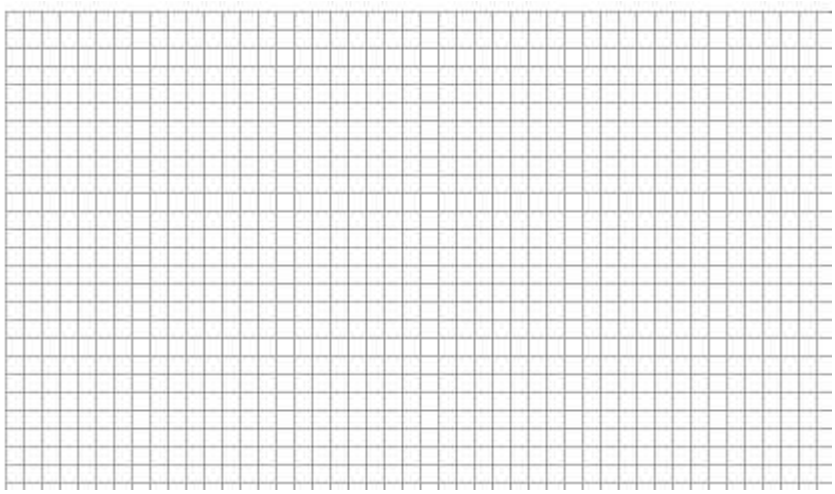
Step No. 2

Exclude the error of position by taking the average of reading in both forward and backward at each point

	First	*Second*	*Third*	*Fourth*	*Fifth*
Forward					
Backward					
Average					

Step No. 3

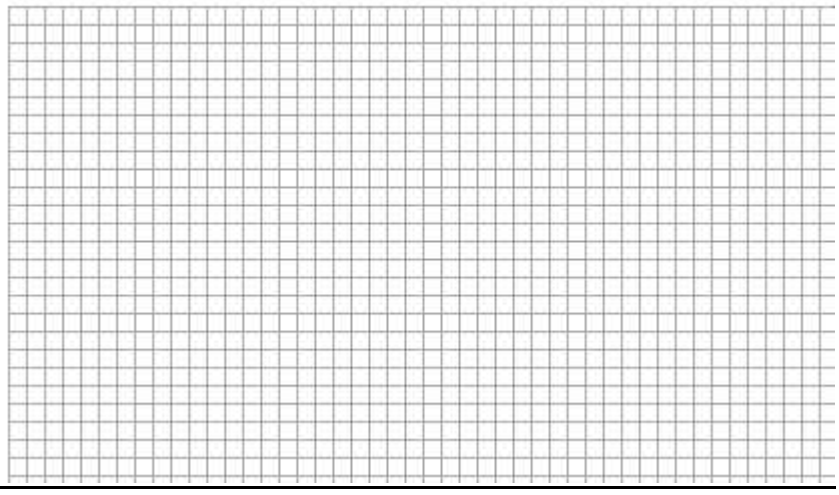
Convert the relative readings to absolute readings



	First	*Second*	*Third*	*Fourth*	*Fifth*
Average					
Absolute					

The readings now are as shown below

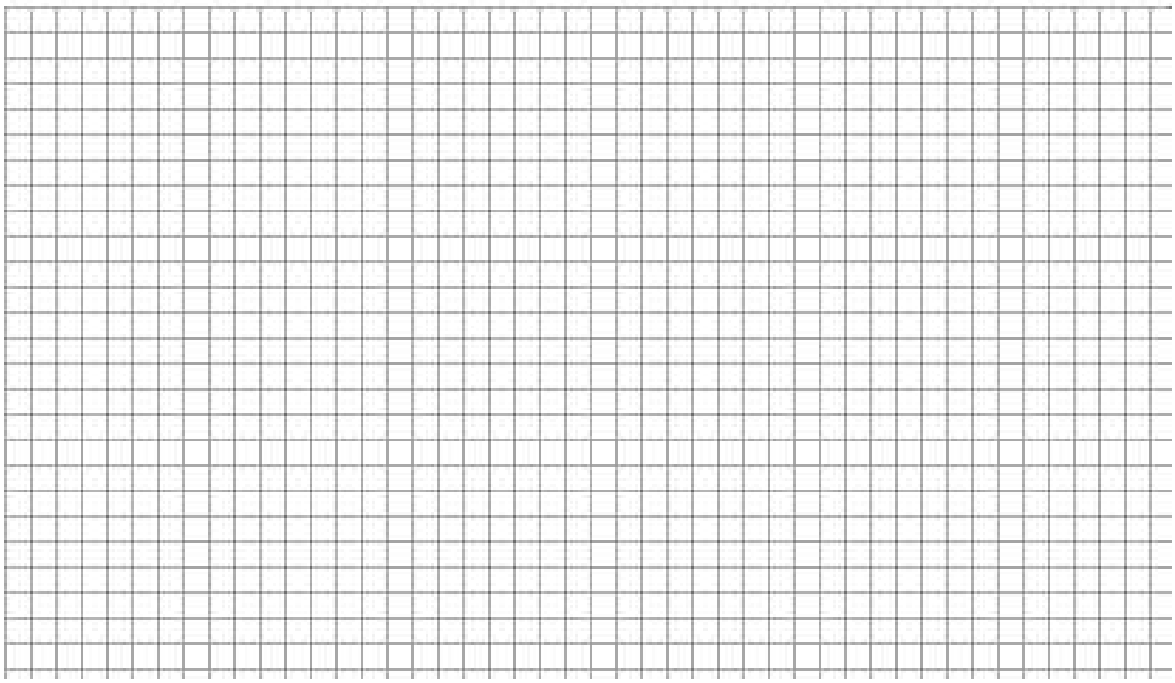
	First	*Second*	*Third*	*Fourth*	*Fifth*
Absolute					



Semi Analytical Solution

Step - 1

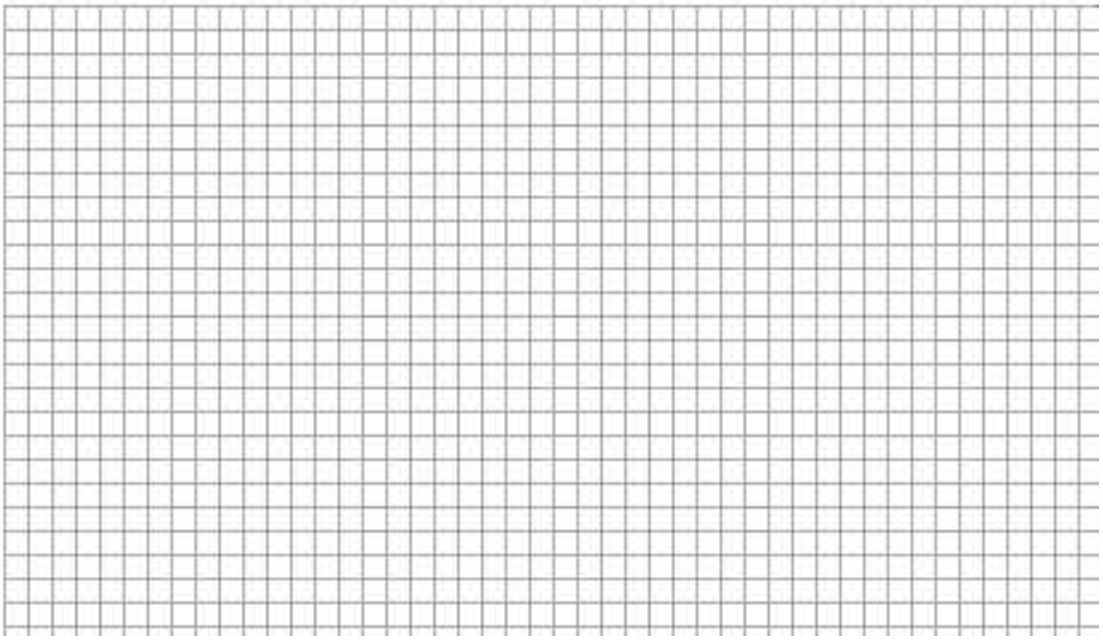
Connect the first and last points. Consider this line as reference line



Step No-2

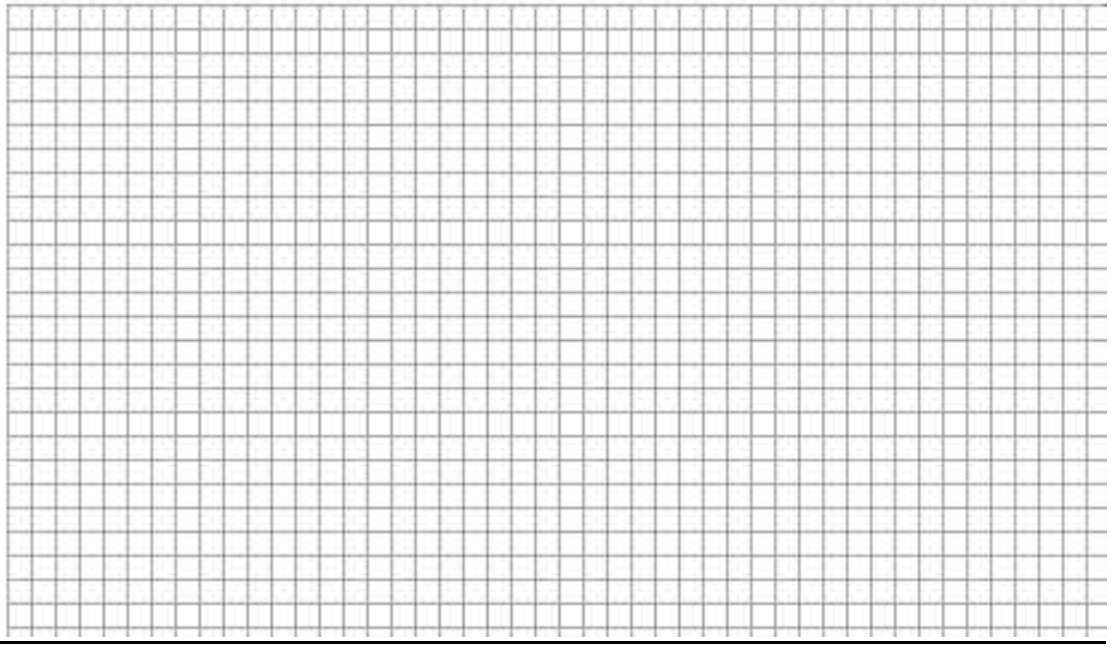
Find the height of the measured points refereed to the reference line instead of the horizontal line.

The following are the measured values measured refereed to the horizontal line



	First	*Second*	*Third*	*Fourth*	*Fifth*
Average					
Absolute					

While the following are their corresponding at the generated reference line



Find the slope m =

Find the height of line (with slope m) at each point

	First	*Second*	*Third*	*Fourth*	*Fifth*
	1	*2*	*3*	*4*	*5*
Absolute					

Calculate the difference between the two corresponding values

to get the measured valued measured from the reference line

	First	*Second*	*Third*	*Fourth*	*Fifth*
Measured to Hl line					
Reference line					
Measured to ref Line					

The previous valued were determined normal to horizontal line. These values have to be normal to the reference line

Calculate the inclination of reference line

tan θ = ……

$\theta \approx$ ……

cos θ = ……

	First	*Second*	*Third*	*Fourth*	*Fifth*
Measured to Hl line					
Reference line					
Measured to ref Line					
Measured normal to ref line cos 3					

Now the out of straightness values are

	First	*Second*	*Third*	*Fourth*	*Fifth*
values					

And the maximum out of straightness is

……

Analytical Solution

As previously mentioned, the point heights are

	First	*Second*	*Third*	*Fourth*	*Fifth*
Absolute					

Step -1

Find the centroid Point

	Point (x)	Height (Y)
	0	
	1	
	2	
	3	
	4	
	5	
Sum	15	
Average = Sum/ no of points	2.5	

The centroid point coordinates are ($X^{\backslash}$, $Y^{\backslash}$) = (2.5, 10.1667)

Step -2

Calculated X and Y for each point related to the centroid point

X at any point = X - ($X^{\backslash}$)

Y at any point = Y - ($Y^{\backslash}$)

Point	Height	X- X\	Y- Y\
0			
1			
2			
3			
4			
5			

Step -3

Find the reference line which is the least square line

$m = \sum (X - X\backslash) (Y-Y\backslash) / \sum (X - X\backslash)^2$

Therefore, two additional column must be determined to calculate

$(X - X\backslash) (Y-Y\backslash)$ and $(X - X\backslash)^2$

Point	X- X\	Y- Y\	(x-x\) (y-y\)	$(X- X\backslash)^2$
1				
2				
3				
4				
5				
6				
Sum				

$m = \sum (X - X\backslash) (Y-Y\backslash) / \sum (X - X\backslash)^2$

= ……

Find the height of line (with slope m) at each point

Point		
1		
2		
3		
4		
5		
6		

Point	Reading	Line	Deviation
1			
2			
3			
4			
5			
6			

Max out of straightness = 2.619 + 2.495 = 5.114

Distance (Xi)	Heights (Yi)	Xc=Xi-Xa	Yc=Yi-Ya	Xc*2	Xc*Yc	Y=mXi	Deviation = Yc-Y
0							
100							
200							
300							
400							
500							
600							
700							
800							
900							
1000							
5500							

Solved Problem

A straight edge of rectangular cross section is checked using sensitive level and the readings of the bubble in the forward directions for the five positions taken along the edge are 0. 6.5, 8.5, 3.5, 7.5 and O, 5.5, 7.5, 2.5, 6.5 respectively. The straight edge when checked was supported its end.

The procedure often determining the mean value, column 4, is to force the end points. A, B to zero and then to adjust all the other points accordingly, then:

X	Y			Heights of pat C`, D`, E`, F`	Deviation from ZAB	Deflec-tion	out of straigh-t ess
	Forward	ba kward	average				
0	o	0	0	0	0	0	0
1	0	0	0	m = 1.4	c-c`=-1.4	Y_1	$Z_1 - Y_1$
2	6.5	5.5	6	2m = 2.3	d-d`=+3.2	Y_2	$Z_2 - Y_2$
3	8.5	7.5	8	3m = 4.2	E-E`=+3.6	Y_3	$Z_3 - Y_3$
4	3.5	2.5	3	4m = 5.6	F-F`=-2.6	Y_4	$Z_4 - Y_4$
5	7.5	6.5	7	5m = 7.o	0	0	0
	$m = \frac{Y_n}{n} = \frac{7}{5} = 1.4$						

Measured distance	Heights Y_i	Centroid $\bar{X}, \bar{Y}$	$X_i = X_i - \bar{X}$	x_i^2	$Y_i = Y_i - \bar{Y}$	$X_i Y_i$	Slope m	$\hat{Y} = mX_i$	Deviation $Y_i - \hat{Y}$
X_1	Y_1	$\bar{X} = \frac{X_i}{n}$							
X_2	Y_2								
X_3	Y_3	$\bar{Y} = \frac{Y_i}{n}$					$m = \frac{X_i Y_i}{X_i^2}$		
⋮	⋮								
X_n	Y_n								
X_i	Y_i			X_i^2		$X_i Y_i$			

X_i	Y_i	$\bar{X}$, $\bar{Y}$	X_i	x_i^2	Y_i	$X_i Y_i$	slope	$\hat{Y} = mX_i$	Deviation
0	0		-500	250000	-7	3500		-6.33	-0.67
100	0		-400	160000	-7	2800		-5.06	-1.94
200	6		-300	90000	-1	300		-3.79	+2.79
300	8	$\bar{X} = \frac{5500}{11}$	-200	40000	+1	-200		-2.53	+3.53
400	3		-100	10000	-4	400	$m = \frac{13900}{1100000}$	-1.27	-2.73
500	7	=500	0	0	0	0	=0.0127	0	0
600	6	$\bar{Y} = \frac{77}{11}$	100	10000	-1	-100		1.27	-2.73
700	10	=7	200	40000	+3	600		2.53	+1.53
800	10		300	90000	+3	900		3.97	-0.79
900	15		400	160000	+3	3200		5.06	+3.06
1000	12		500	250000	+5	2500		6.33	+1.33
5500	77			1100000		13900			