יום עיון הנדסה ואיכות בתהליכי עיבוד שבבי לשכת המהנדסים והאדריכלים 2022

רונן קומריאן,
עובד בקמ"ג בתחום הפיתוח, תכן הנדסי, ובעבר גם בעיבוד שבבי, משנת 1998 .
מלמד את נושא ה – GD&T במכללה להנדסה סמי שמעון, קמ"ג

<u>השכלה:</u>

תואר ראשון בהנדסת מכונות, מהמכללה להנדסה SCE באר שבע.
תואר ראשון בניהול, האוניברסיטה הפתוחה.
תואר שני בהנדסת אנרגיה, אוניברסיטת בן גוריון.

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<u>קורסים:</u>

1. **ASME** - "Geometric Dimensioning & Tolerancing Fundamentals + Advanced Applications with Stacks and Analysis "- Course (2010)
2. **ASME** – "Dimensioning and Tolerancing Principles for Gages and Fixtures" - Course (2012)

<u>הסמכות:</u>

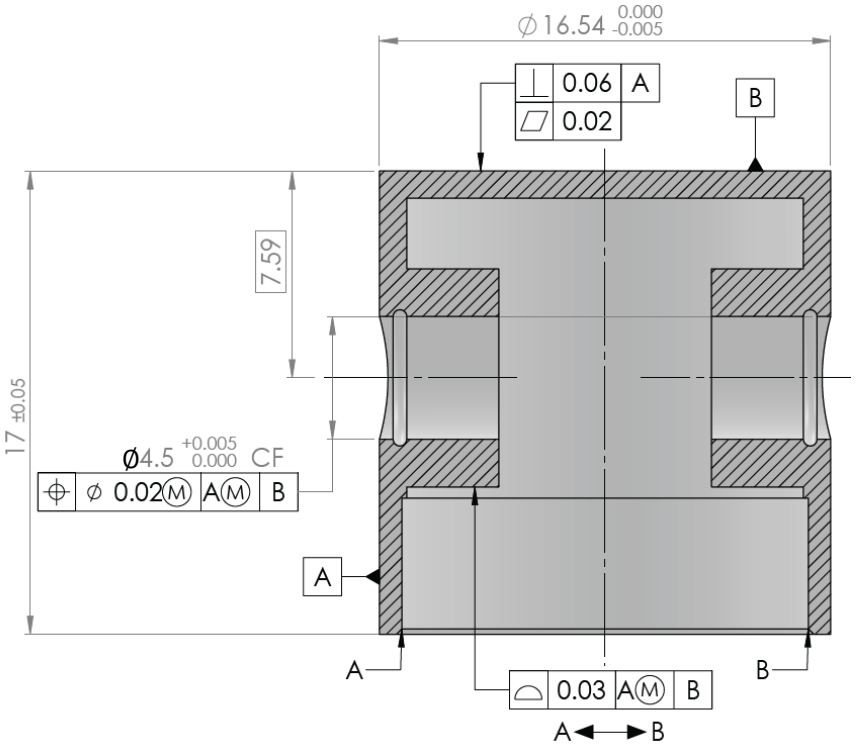
1. **GDTP - Geometric D**imensioning & **T**olerancing **P**rofessional – **Senior Level** - 3355
2. **GDTP - Geometric D**imensioning & **T**olerancing **P**rofessional - **Technologist Level** – 0843

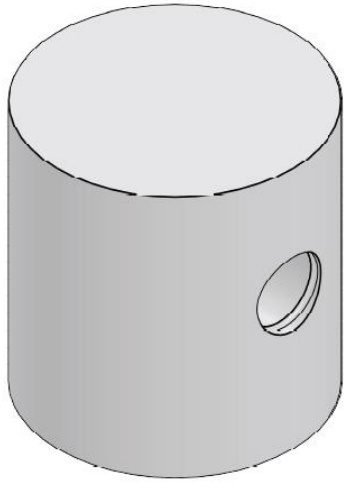
Table of Contents

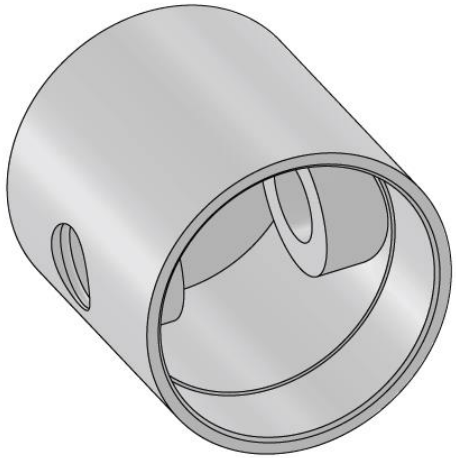
GD&T – international Drawing language

international Drawing language, Applied drawings to describe a mechanical parts.

- **Rules:** rule #1, rule #2…
- **Settings:** Assembly, Part, feature, datum, DRF…
- **Tools:** dimensions, shape, orientation, location…







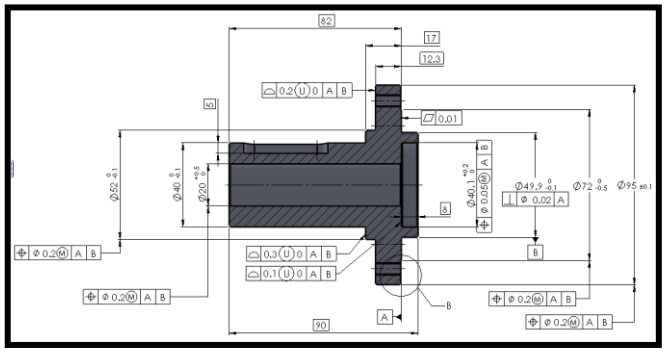
What is GD&T

GD&T - precise language

Geometry dimensions and tolerances is a precise language.

DESIGN

The information is define more clearly by the designer



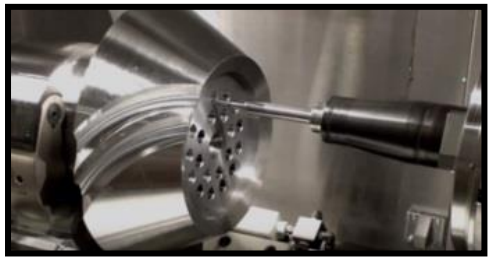
Mechanical

GD&T

Engineer

MANUFACTURING

The part is better understood by the manufacturer



QUALITY

The Inspector measure the part as defined by the designer

What is GD&T

GD&T - language that provides uniformity

Uniform language

- Engineering
- Manufacturing
- Inspection
- Development
- Customer
- Assembly
- Materials
- Gage Planning
- Marketing

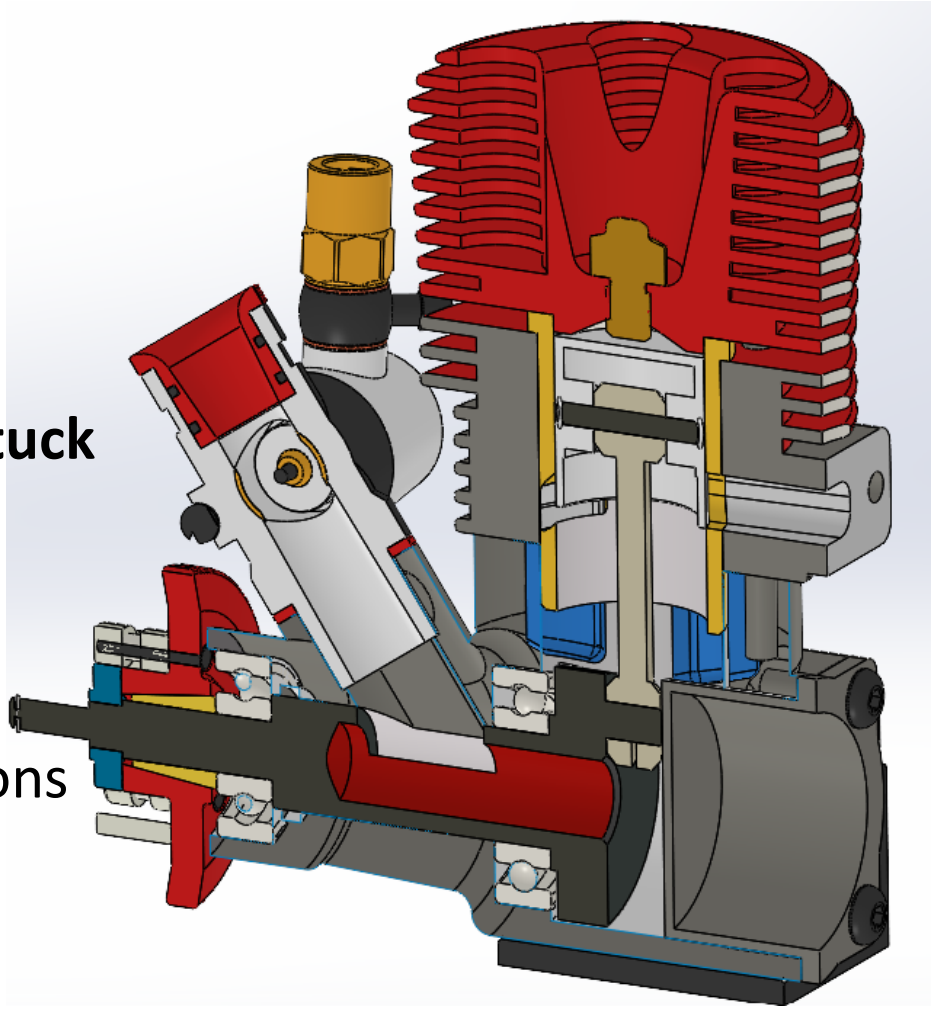
same drawings interpretation

The immediate effect is

- reduce disputes, guesswork and assumptions
- drawing clarity
- follow the manufacturing process

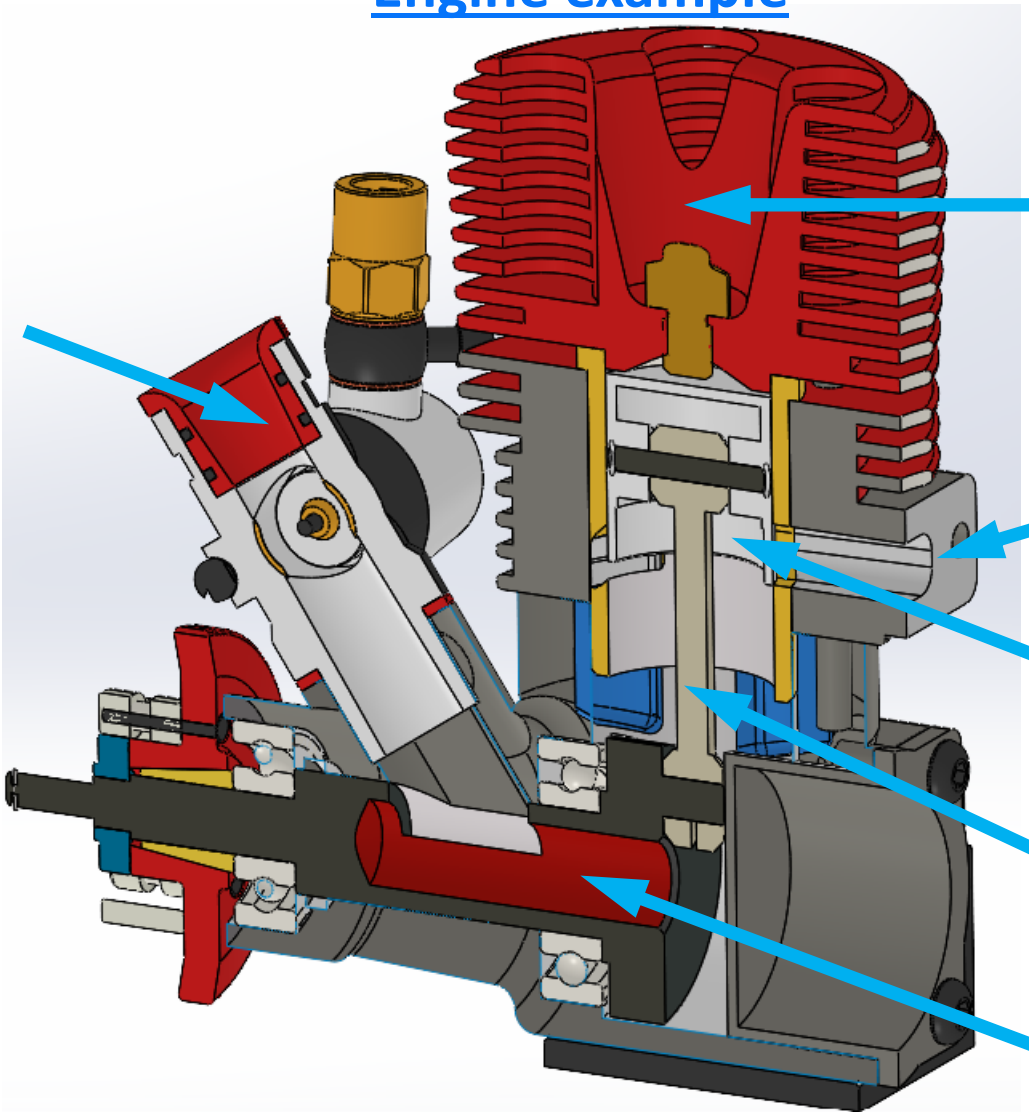
GD&T – Advantages

- Functional design
- Design by limits
- Maximum **match between components**.
- The ability to **calculate tolerance stuck** easily and systematically
- Process repeatability.
- Reduction of product disqualifications
- Shorter production duration.
- Reduce costs.



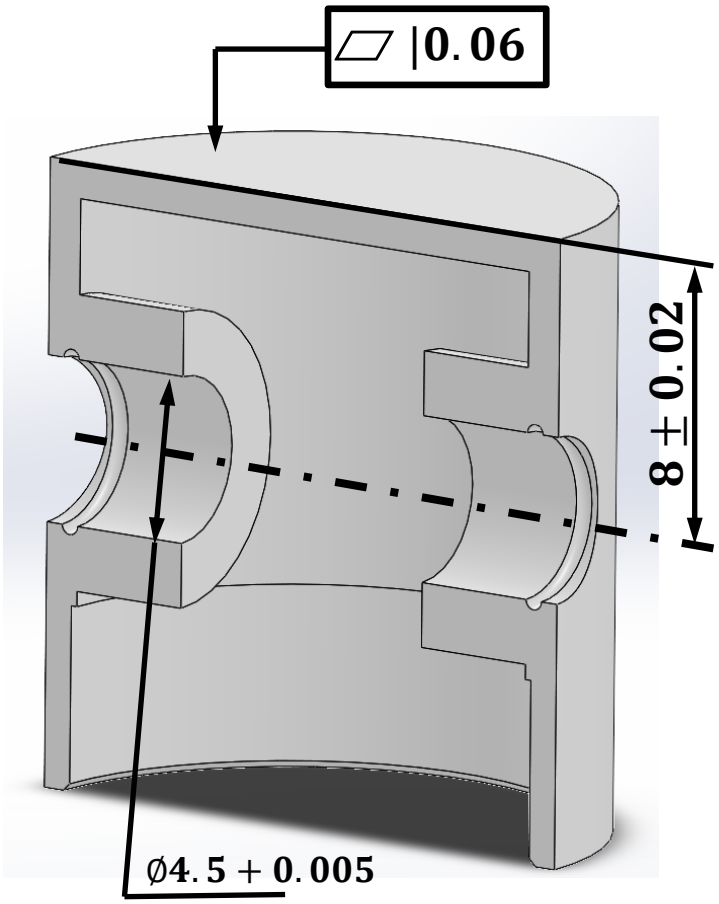
What is GD&T

Engine example



Size Does Not Control Interrelationship between Individual feature

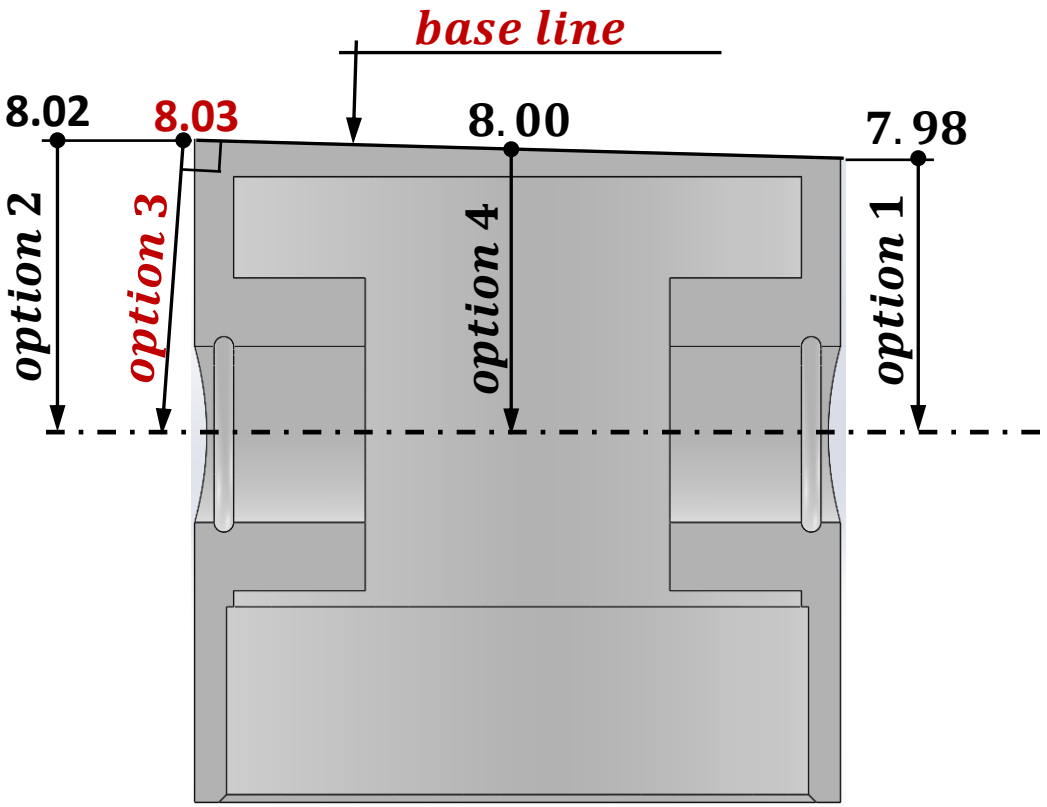
Coordinate Dimension Drawing



Notes:
General Tolerance ±0.2
General Angle Tolerance ±1°

cylinder

Means this



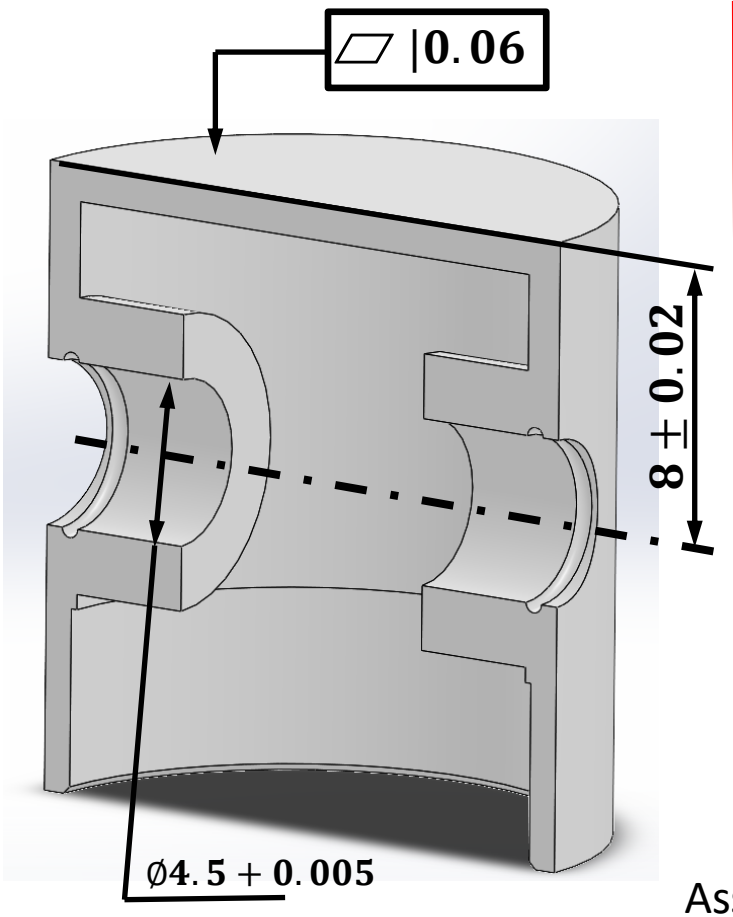
Questions

Assuming that the hole location measured is relative to the surface:

1) which option is the correct measure?
2) What is the reported measurement?

Size Does Not Control Interrelationship between Individual feature

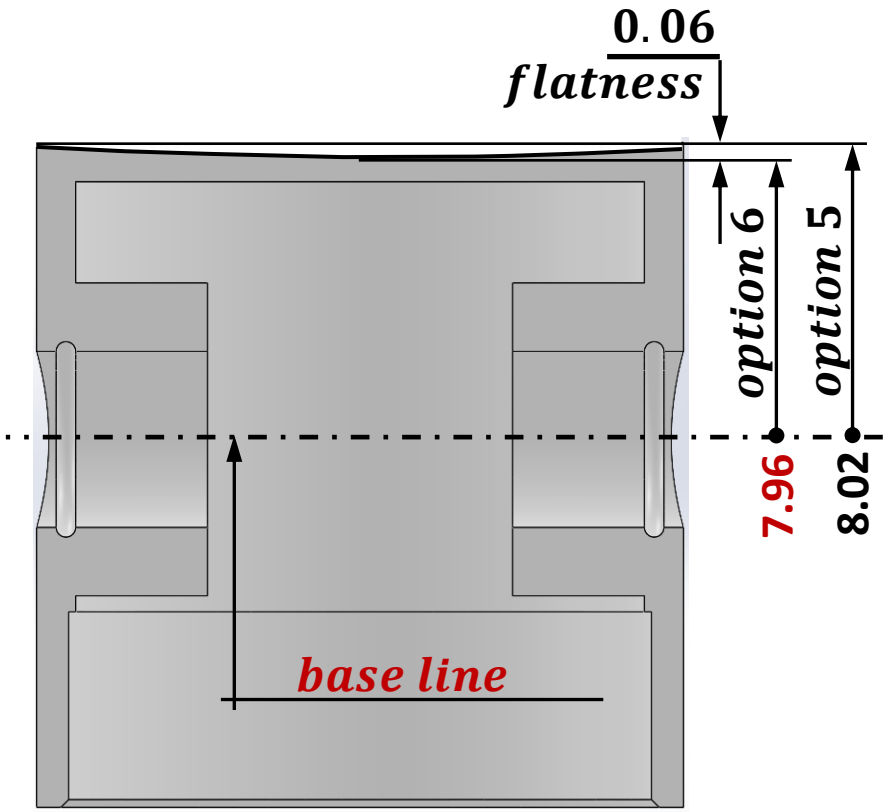
Coordinate Dimension Drawing



Notes:
General Tolerance ±0.2
General Angle Tolerance ±1°

cylinder

Means this



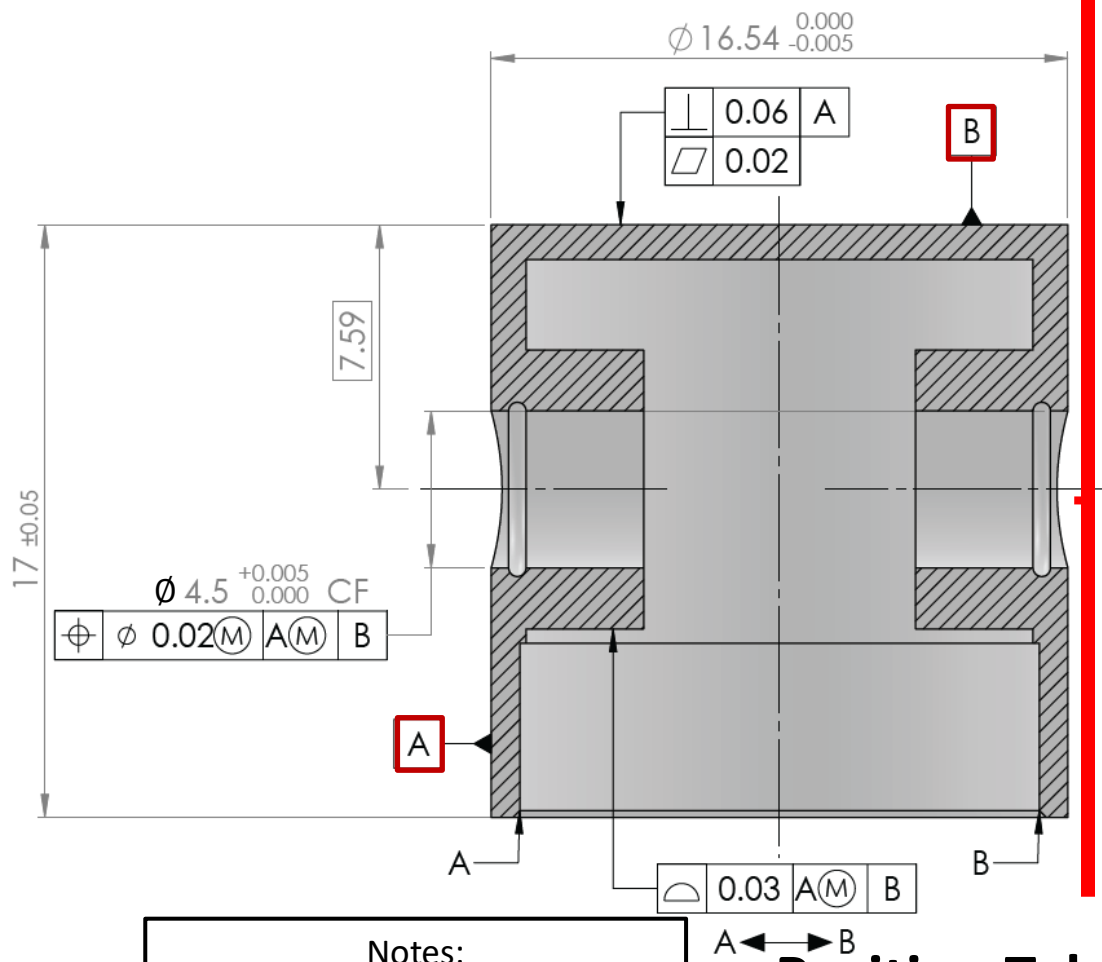
Questions

Assuming that the surface is measured relative to the hole :

1) which option is the correct measure?
2) What is the reported measurement?

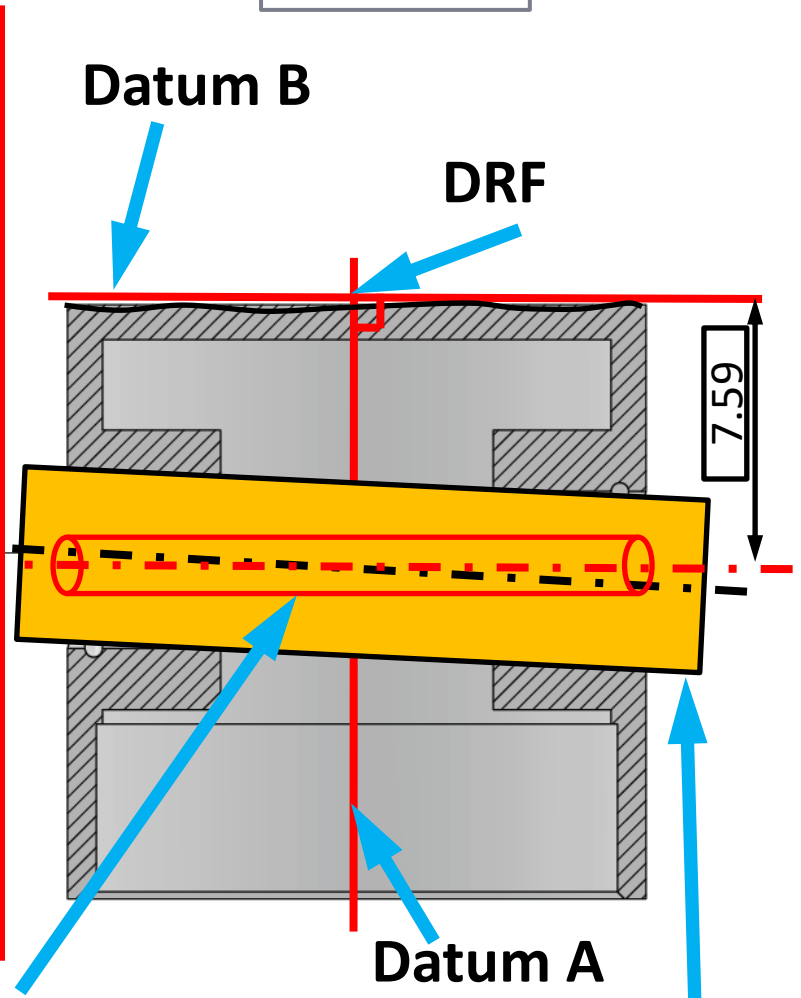
Size Does Not Control Interrelationship between Individual feature

GD&T Drawing



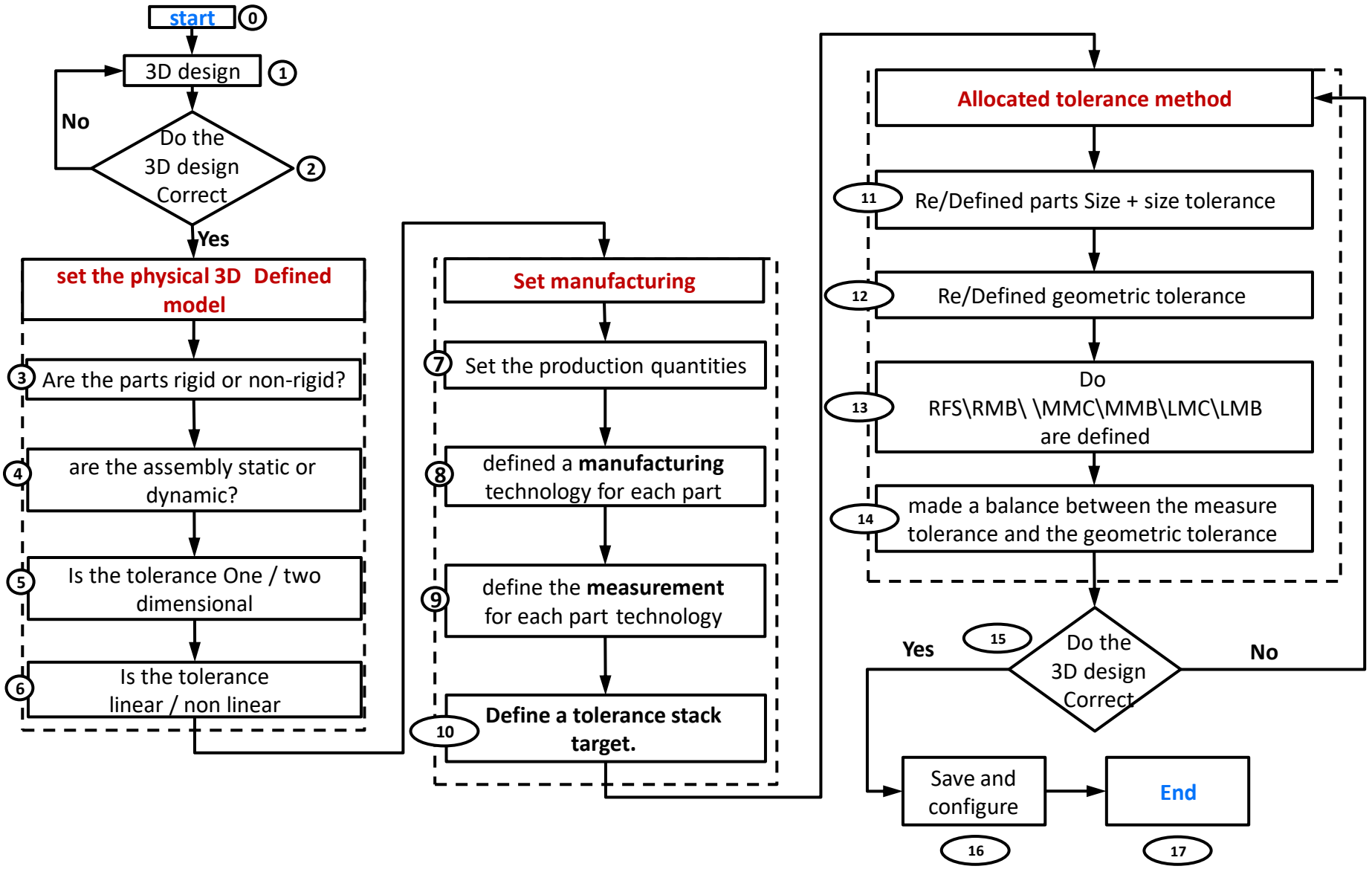
cylinder

Means this

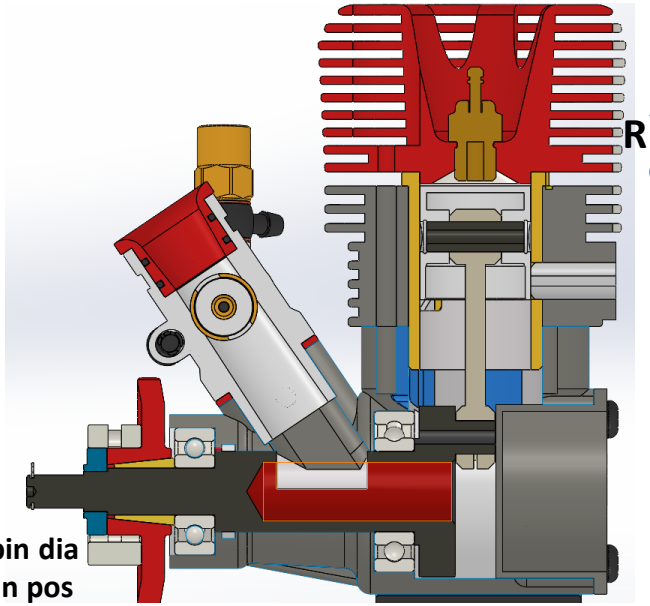


Notes:
General Tolerance ±0.2
General Angle Tolerance ±1°

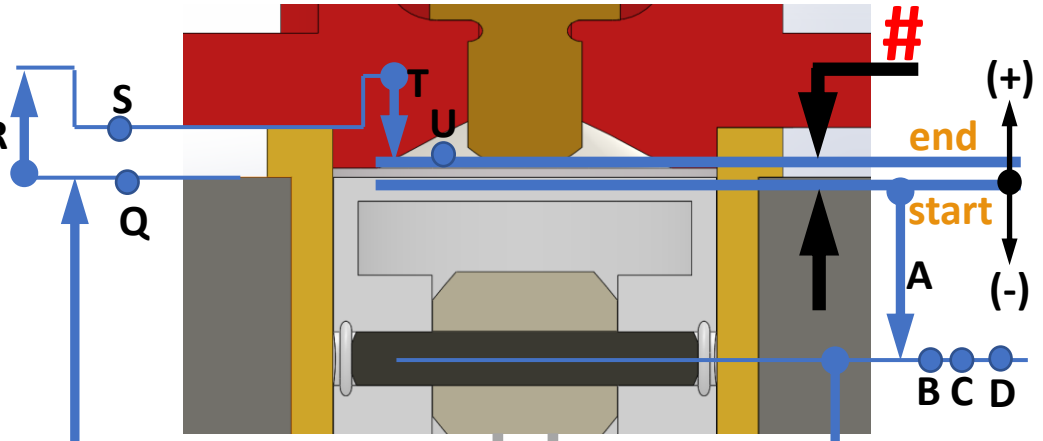
Set 3D design and Allocated tolerance method

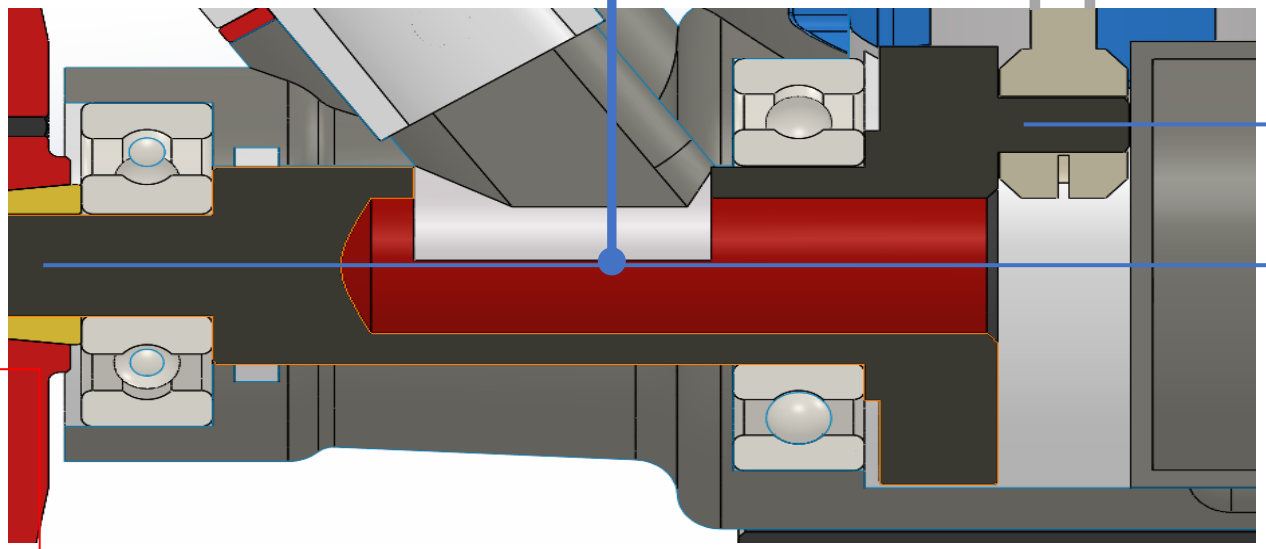


GD&T Tolerance stuck



A – hole length
B – hole pos
C - hole dia
D - pin dia
E - road length
F – road pos
G – road dia
H – crank shaft pin dia
I – crank shaft pin pos
J – crank shaft pin length
K – crank shaft bearing dia
L – bearing inside dia
M – bearing outside dia
N – house bearing dia
O– house bearing pos
P – house length
Q – house profile
R – sleeve thickness
S – sleeve profile
T – head length
U – sleeve profile



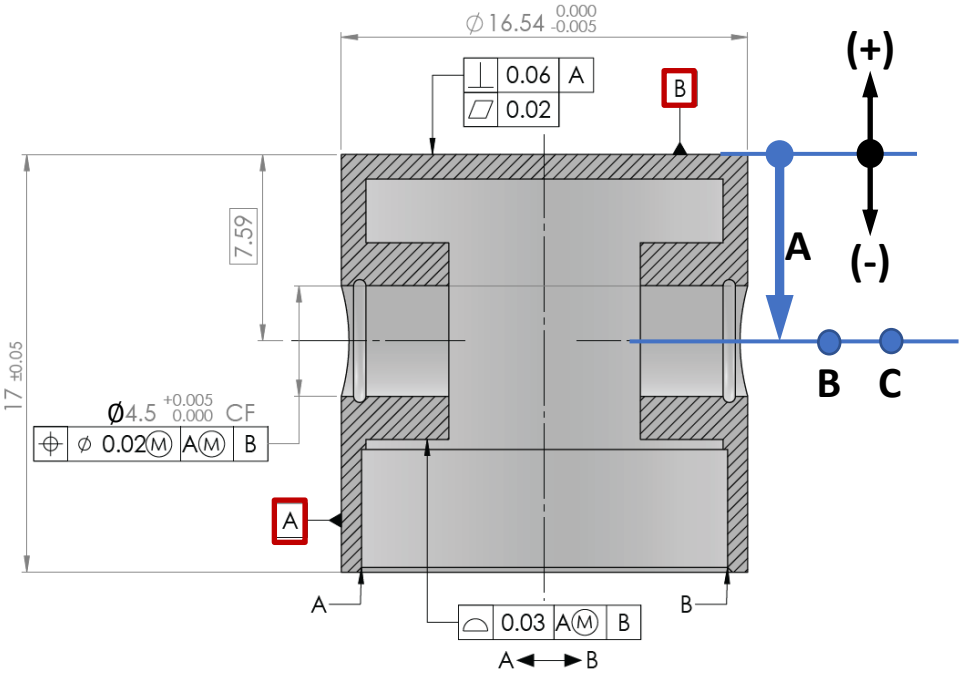


 # = Nominal Size 0.23 mm

Min Dis = 0.02

Each equal tol = 21 elements / 0.21 nom size = ±0.01 mm

GD&T Tolerance stuck

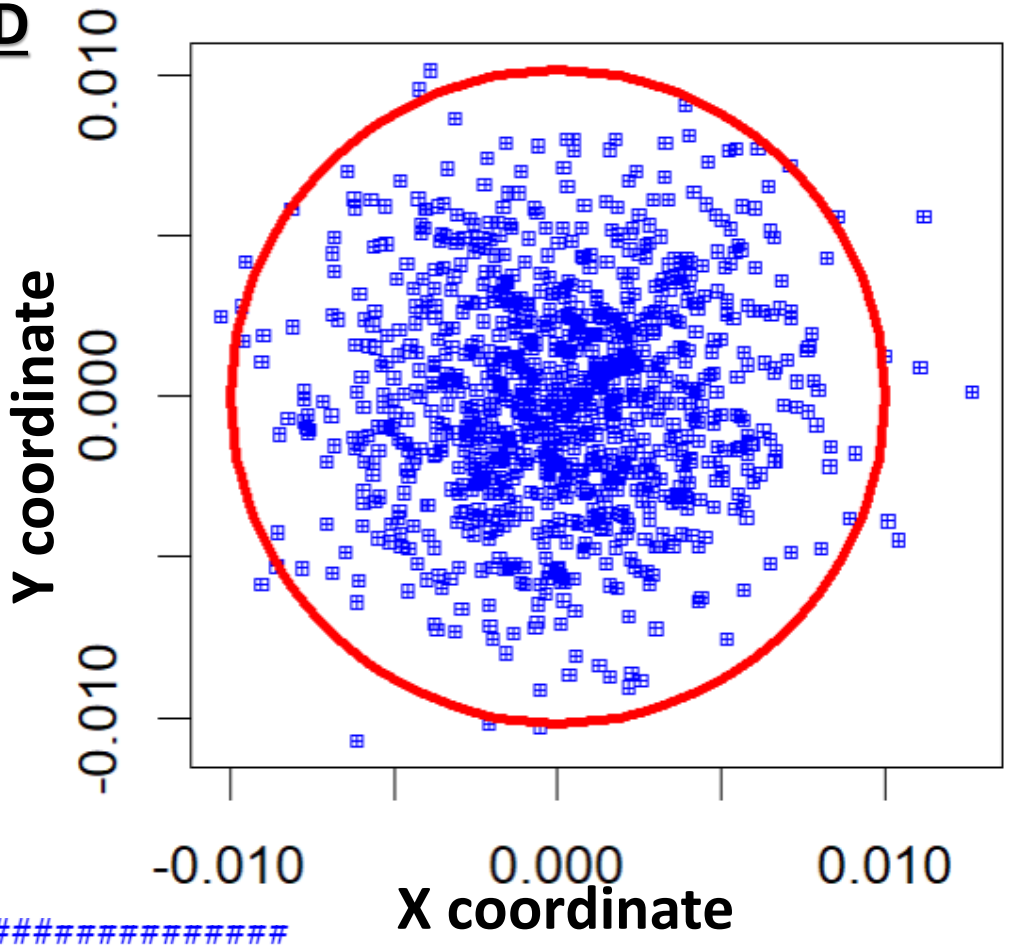


RULE NUMBER 1				
MOVE T0		MAXIMUM		MINIMUM
RIGHAT →	(+)	(+) max	(+)	(+) min
LEFT ←	(-)	(-) min	(-)	(-) max

part number	DIM	description from/to		MAXIMUM		MINIMUM	tolerance
			(+)	(+) max	(+)	(+) min	
			(-)	(-) min	(-)	(-) max	
cylinder	A	Datum B to hole position BSC DIM	(-)	7.59	(-)	7.59	0
cylinder	B	Hole position	(+)	0.02	(+)	0.02	0.02
cylinder	C	Hole size	(+)	0.005	(+)	0	0.005
pin	D		(-)	0	(-)	0.005	0.005
.....	.....	.....		.....		.....	.....
		SUB TOTAL					0.03
		ANSWER					TOL
comment							OPTMIZED?
							YES
							NO

Define Position tolerance by SD

1. **Target:** 0.02 position diameter circle
2. **1000 points of normal distribution.**
3. **standard deviation 0.0035**



Results

```
> ##########################################
> print(paste0("the number of points in the circle are:",num_count))
[1] "the number of points in the circle are:981"
> print (paste0("the number of points in the circle in present are:",(num_count*100)/
num, paste0("%")))
[1] "the number of points in the circle in present are:98.1%"
> ##########################################################################
```

Define tolerance by SD

```
1
2
3  sd1<-0.004  # standart deviation
4  x <- rnorm(num, mean=0, sd=sd1)
5  hist(x, probability=TRUE)
6  xx <- seq(min(x), max(x), length=1000)
7  lines(xx, dnorm(xx, mean=0, sd=sd1))
8  ########################################
9  #create normal distribution to y coordinate
10 y <- rnorm(num, mean=0, sd=sd1)
11 #print(y)
12 hist(y, probability=TRUE)
13 yy <- seq(min(y), max(y), length=1000)
14 lines(yy, dnorm(yy, mean=0, sd=sd1))
15 ########################################
16 #start
17 print (r1<- c(0.01))
18 print (a1<- 2*r1)
19 print (s2<- pi*r1^2)
20 ########################################
21 num_count <- 0 # count number of point that is in the circle
22 num_count2 <- 1 # its count from the first vector position
23 ########################################
24 vect1 <- c(y) # Generating integers without replacement
25 vect2 <- c(x) # Generating integers without replacement
26 vect3 <- c((((vect1)^2)+((vect2)^2))^0.5)
27 ########################################
28 print(vect1)
29 print(vect2)
30
```

Create X-axis coordinates

Create Y-axis coordinates

Create radius, diameter, area

Define tolerance by SD

```
print(vect2)
print(vect3)
for(vect in 1:num){
    if (r1 > vect3[num_count2]){
        num_count <- num_count+1  #its count number of point that is in the circle
      } else {
            if (vect1[num_count2] > r1){
      num_count3 <- num_count3+1
       } else {
              if (vect1[num_count2] < -r1){
          num_count3 <- num_count3+1
            } else {
       if (vect2[num_count2] > r1){
             num_count3 <- num_count3+1
            } else {
       if (vect2[num_count2] < -r1){
          num_count3 <- num_count3+1
          }
    }}}}
             num_count2 = num_count2+1
  }
prnt.space(c(""))
##############################################
plot.new()
library(plotrix)#we must to install this library
plot(vect1,vect2,col="blue", pch=12, cex=0.5)
draw.circle(0, 0, r1, border = "red", lwd = 3)
##############################################
print(paste0("the number of points in the circle are:",num_count))
print (paste0("the number of points in the circle in present are:",(num_count*100)/num, paste0("%")))
```

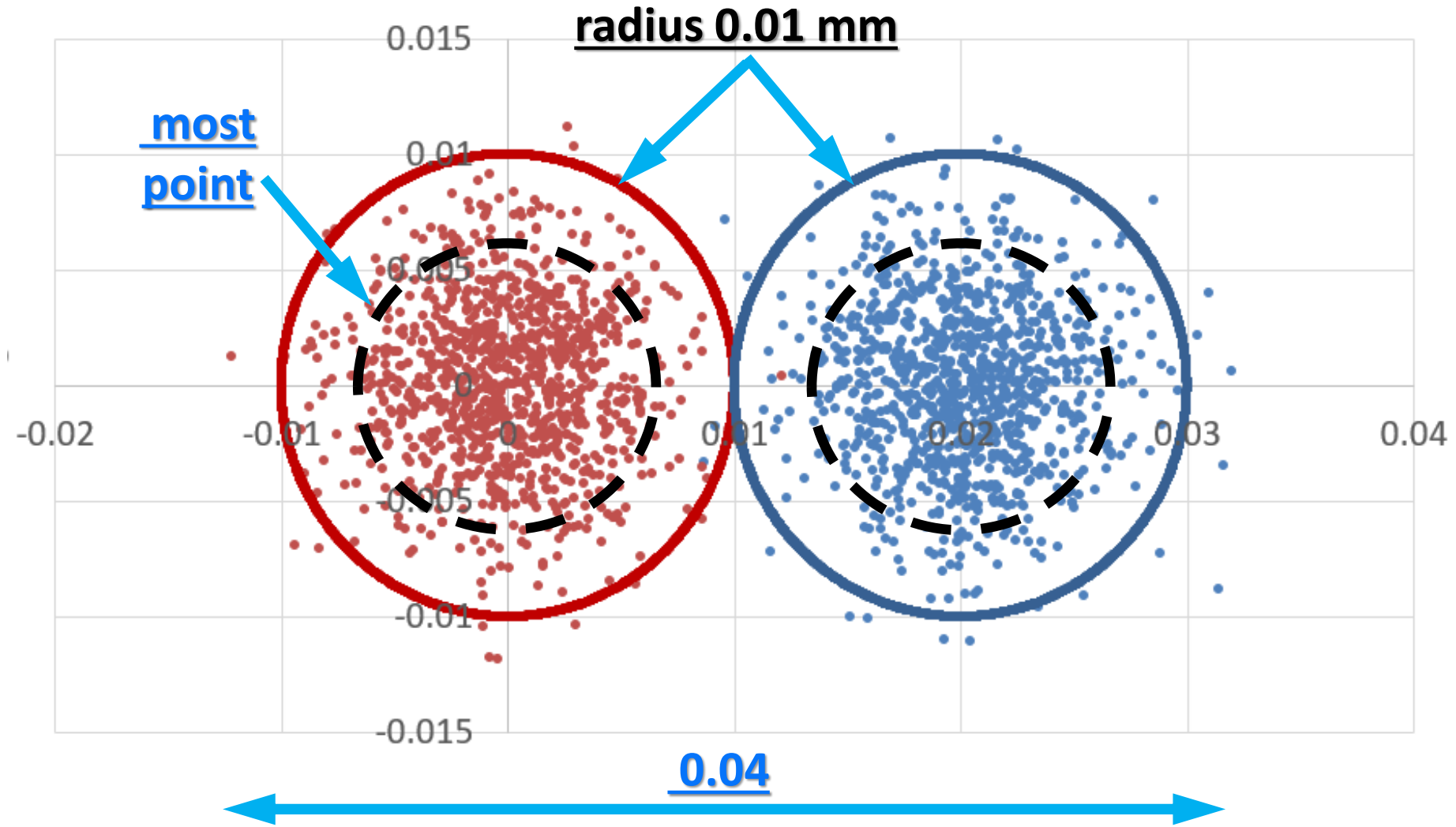
Create loop
If the coordinate is in the circle or no and a count that

plot
Circle, points

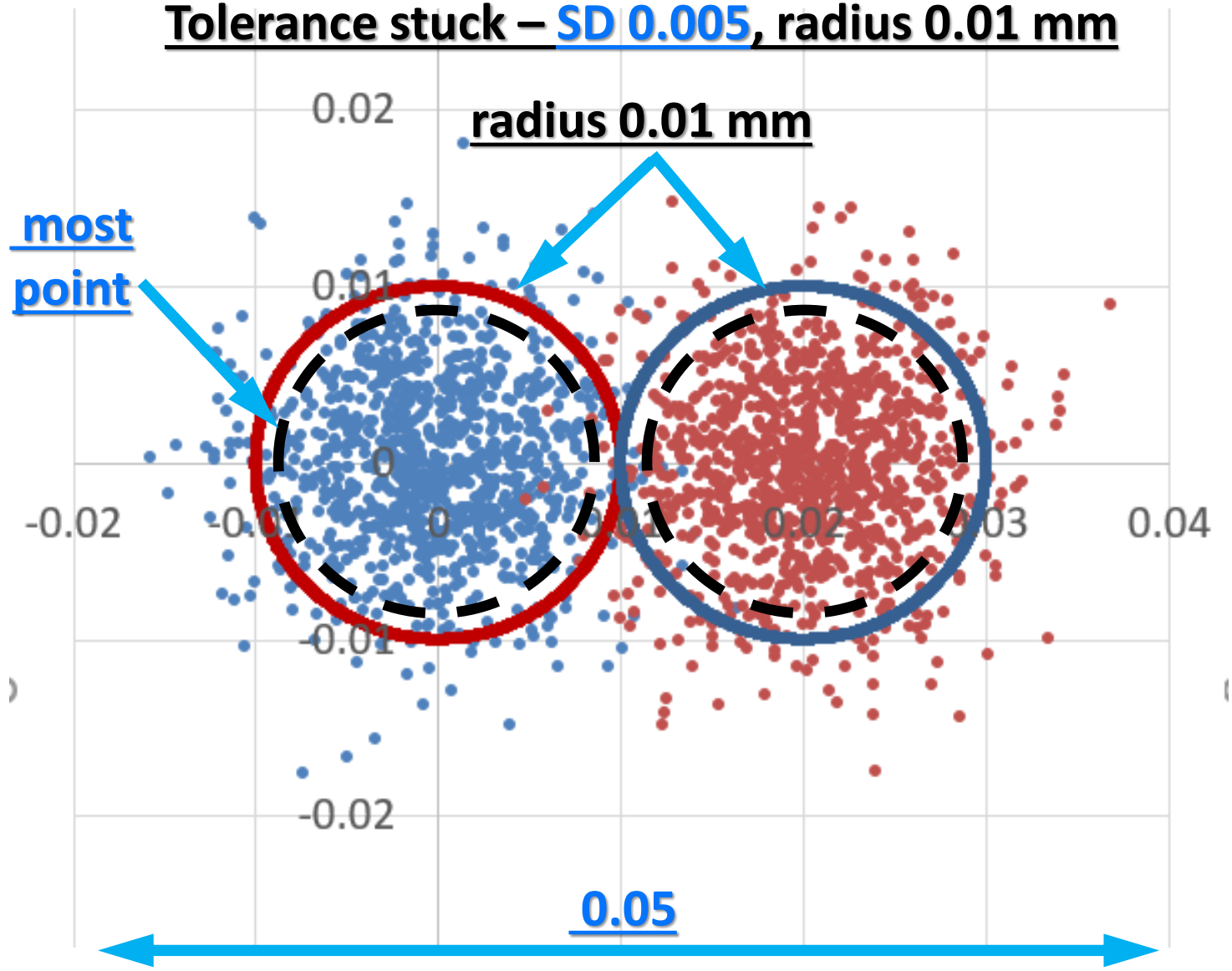
print
Number of points that inside the circle

Manufacturing by SD

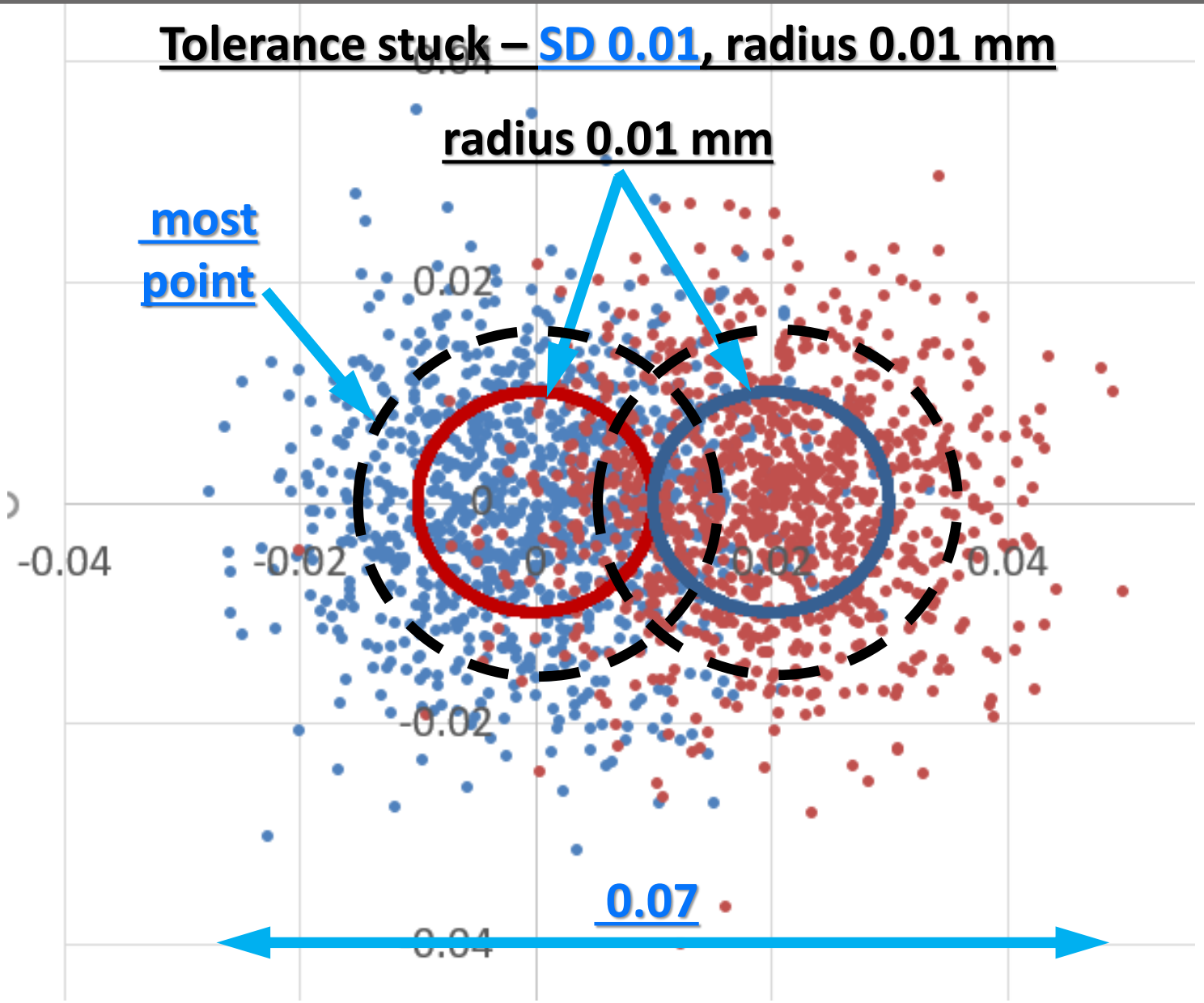
Tolerance stuck – SD 0.0035, radius 0.01 mm



Manufacturing by SD



Manufacturing by SD

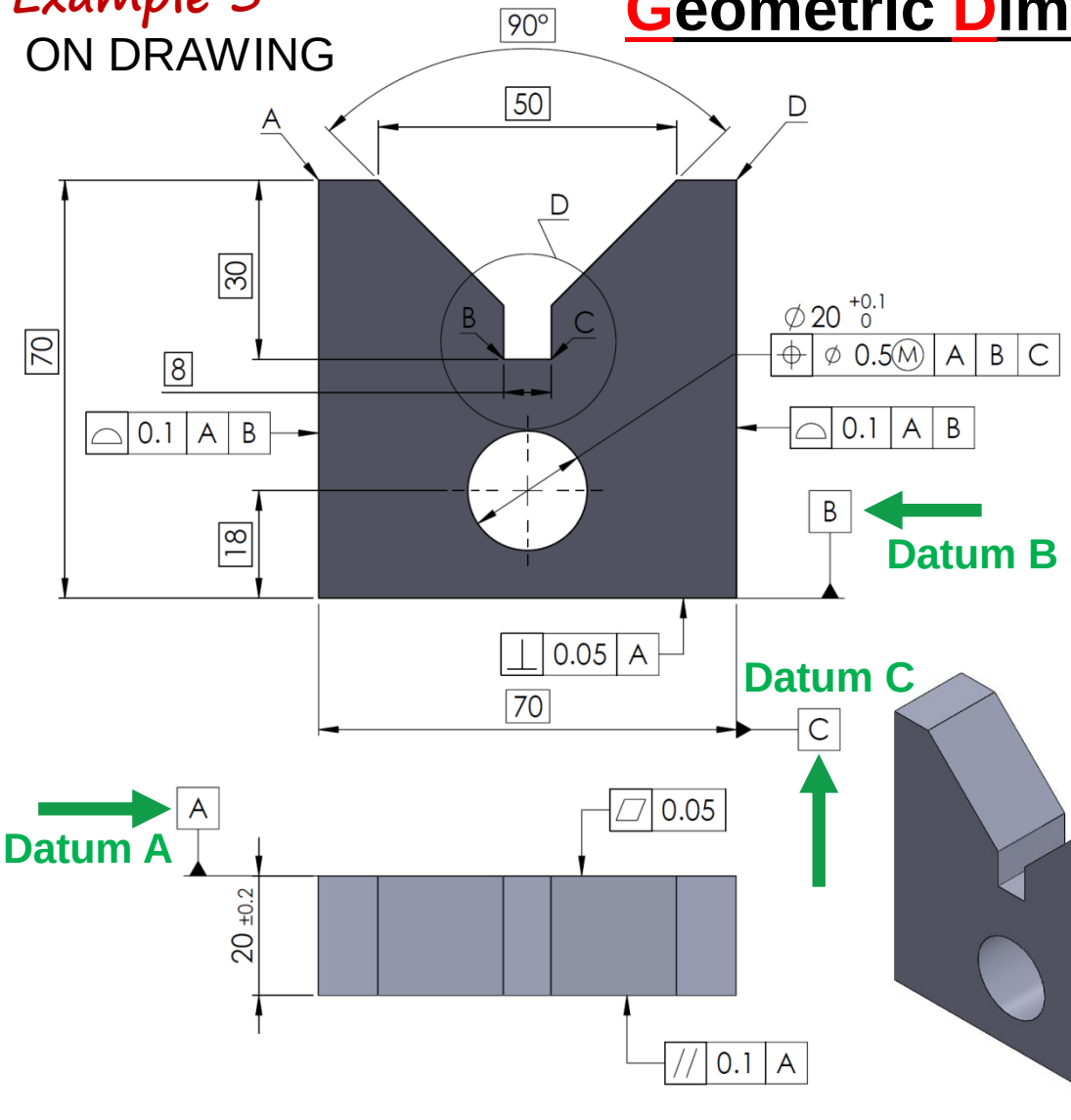


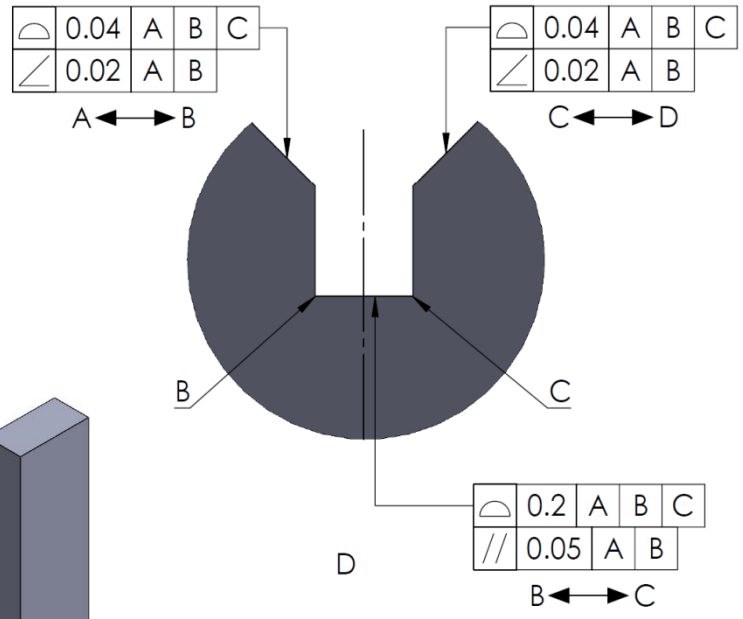
What is required to design and manufacture this component

Example 3

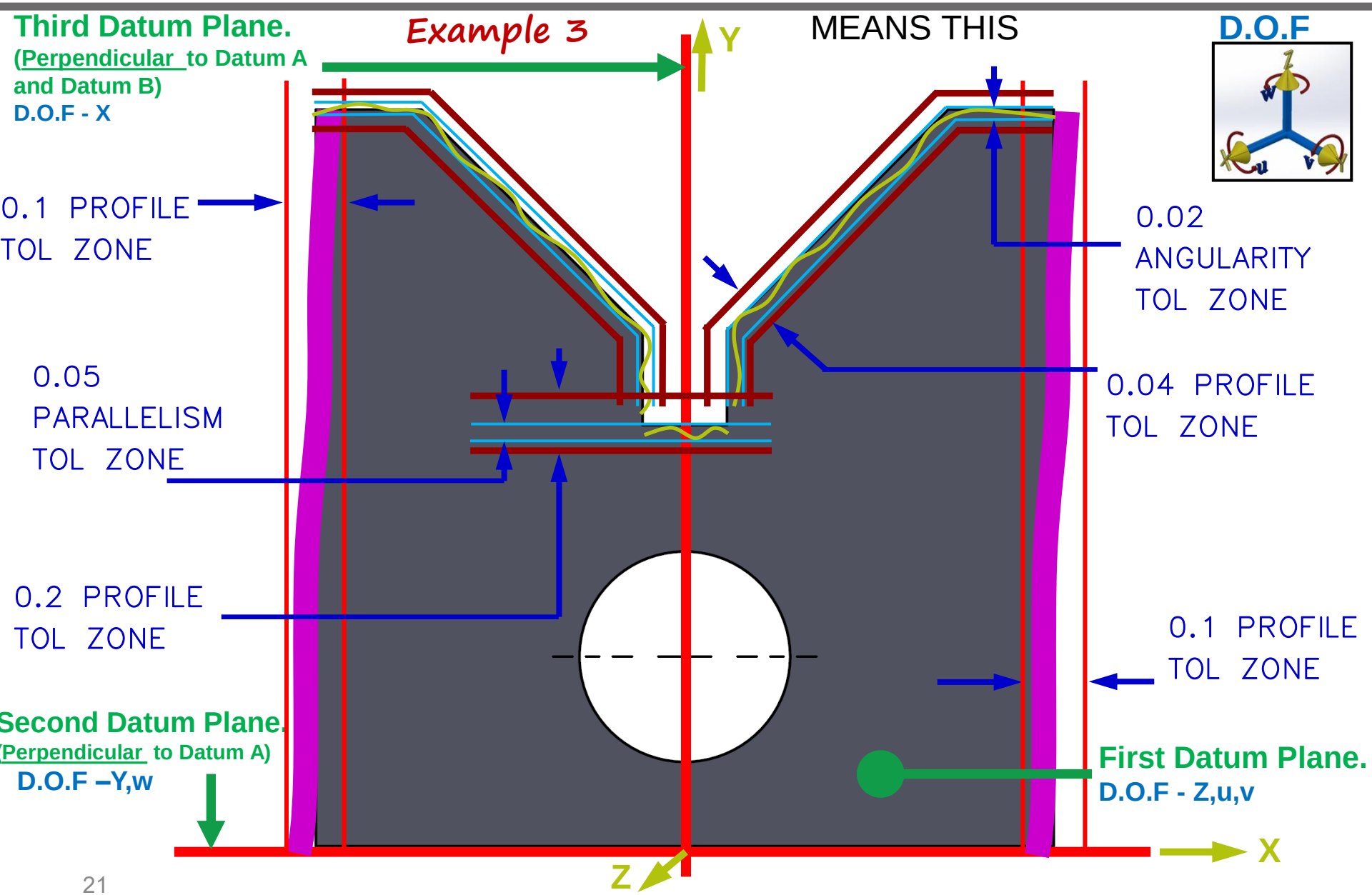
ON DRAWING

Geometric Dimensioning & Tolerancing





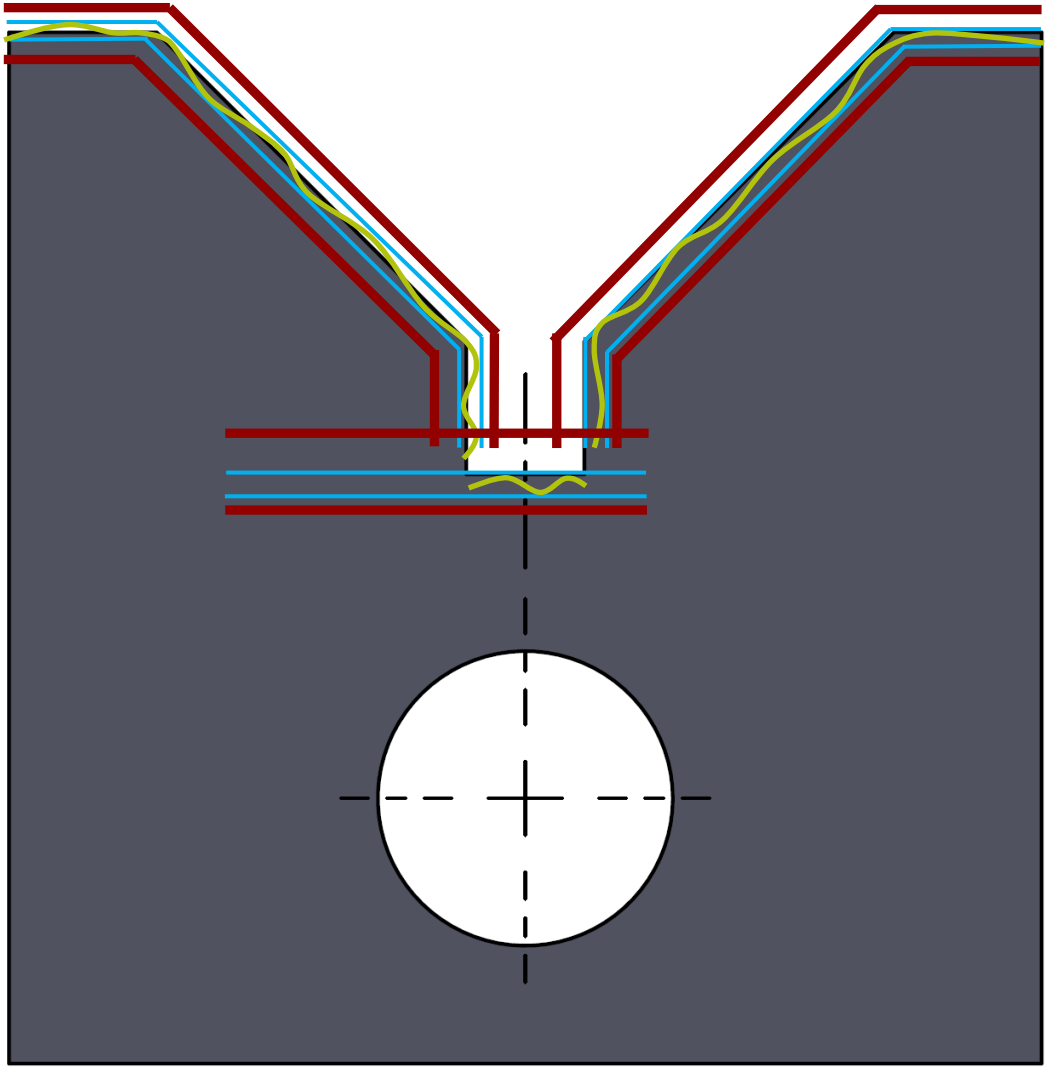
What is required to design and manufacture this component



What is required to design and manufacture this component

Example 3

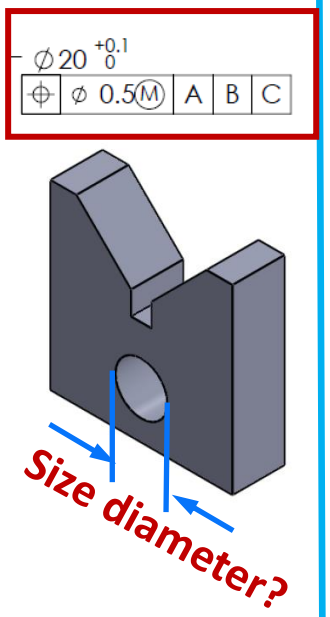
MEANS THIS



Example 3

How to measure a hole diameter

On drawing



Several methods of measurement

- caliper →

- Telescoping Gage Set →

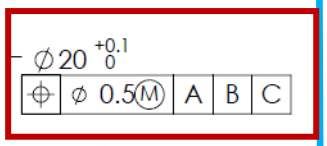
- pin gage →

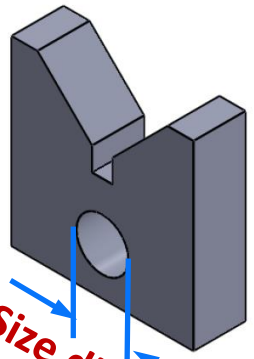
- Cmm measurement →

Example 3

How to measure a hole diameter

On drawing



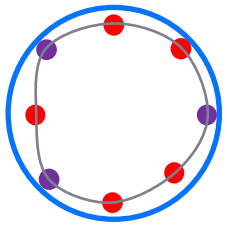


Cmm measurement

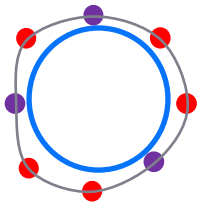
For a cylinder, a minimum of 6 points is required
3 points in 2 sections

cmm results option

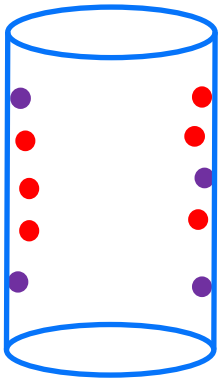
1) circumscribed cylinder



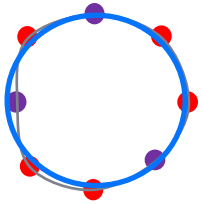
2) inscribed cylinder



3) AME Related \ Unrelated



4) Average



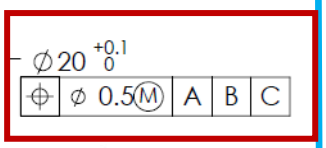
Example 3

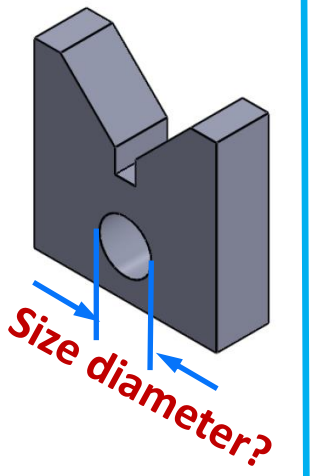
How to measure a hole diameter

Cmm **Average** result:

5 measurement points were taken

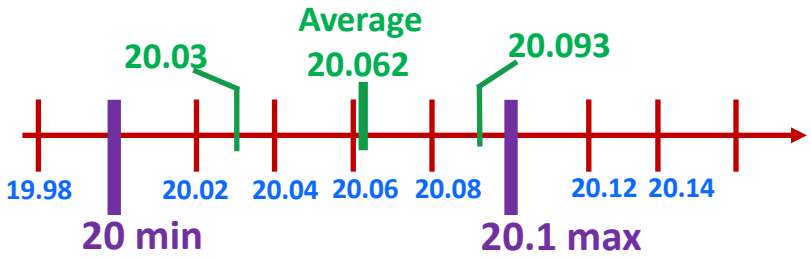
On drawing



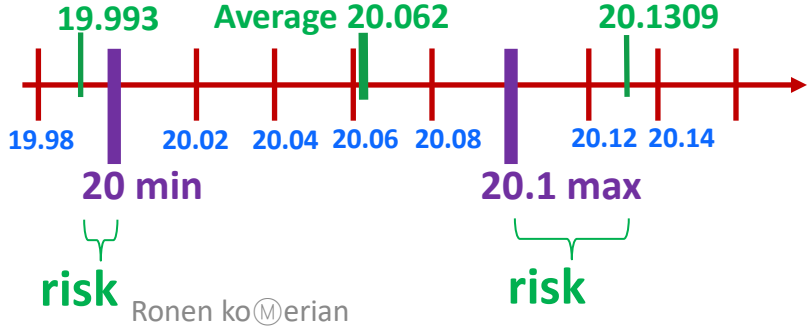


	Sampling number	Diameter Measurement
	1	20.07
	2	20.09
	3	20.09
	4	20.01
n=	5	20.05
	$\bar{x}$ Average	**20.062**
	$\hat{s}$ standard deviation	**0.033466401**
	D.O.F=n-1	5-1=4

Confidence interval		90%		
α		0.1		
$\alpha/2$		0.05		
$t(\alpha/2)$		2.132		
Minimum value	**>**	**μ**	**>**	**Maximum value**
20.03009115	**>**	**μ**	**>**	**20.09390885**



Confidence interval		99%		
α		0.01		
$\alpha/2$		0.005		
$t(\alpha/2)$		4.604		
Minimum value	**>**	**μ**	**>**	**Maximum value**
19.99309364	**>**	**μ**	**>**	**20.13090636**



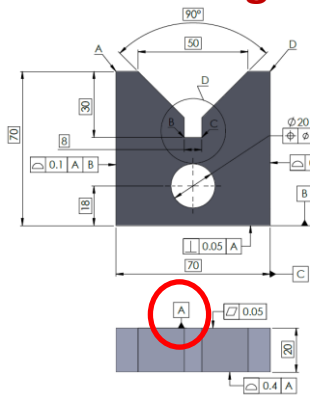
Confidence interval equation

$$p\left(\bar{x} - t_{\frac{\alpha}{2}}\frac{\hat{s}}{\sqrt{n}} < \mu < \bar{x} + t_{\frac{\alpha}{2}}\frac{\hat{s}}{\sqrt{n}}\right) = 1 - \alpha$$

Example 3

How to measure a Datum plane

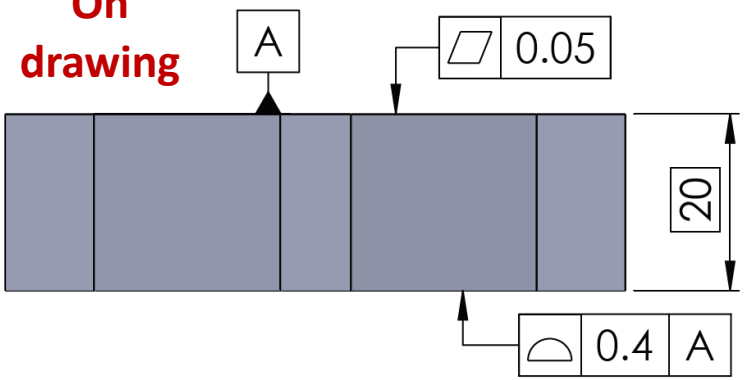
On drawing



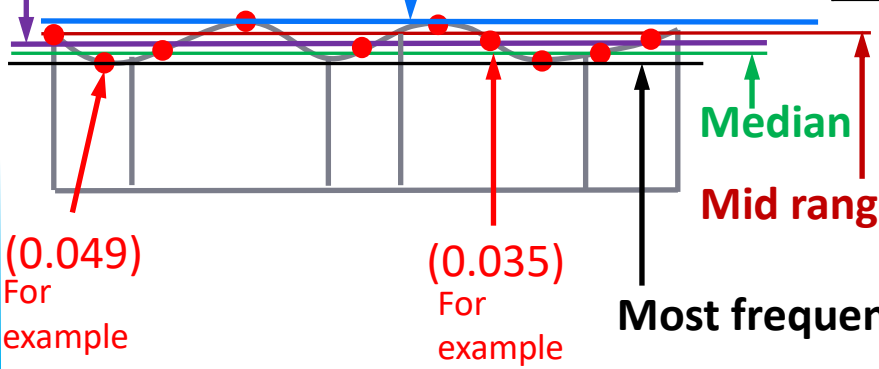
Cmm **Average** result:

10 measurement points were taken

On drawing



Means this



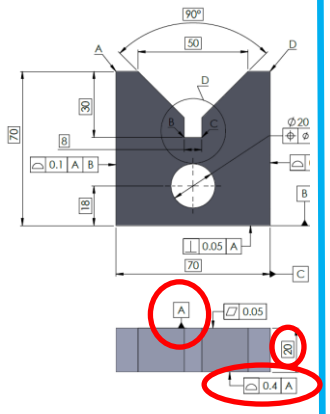
1	0.008	$\sqrt{\frac{\sum_{i=1}^{n}(x_i-\tilde{x})^2}{n}}$
2	0.01	
3	0.035	
4	0.012	
5	0.048	
6	0.049	
7	0.045	
8	0.049	
9	0.05	
10	0.025	

$\tilde{x}$-indicators		Least squares root
Average	0.0331	0.01683
mid-range	0.029	0.01732
Median	0.04	0.01819
Most frequent value	0.049	0.02315

Example 3

How to measure a Datum plane

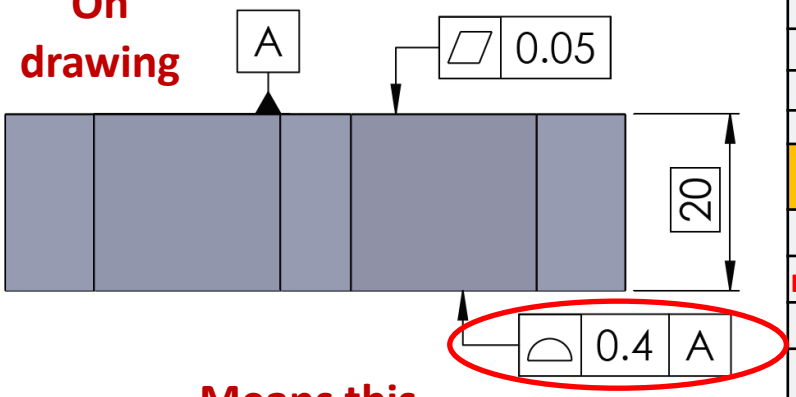
On drawing



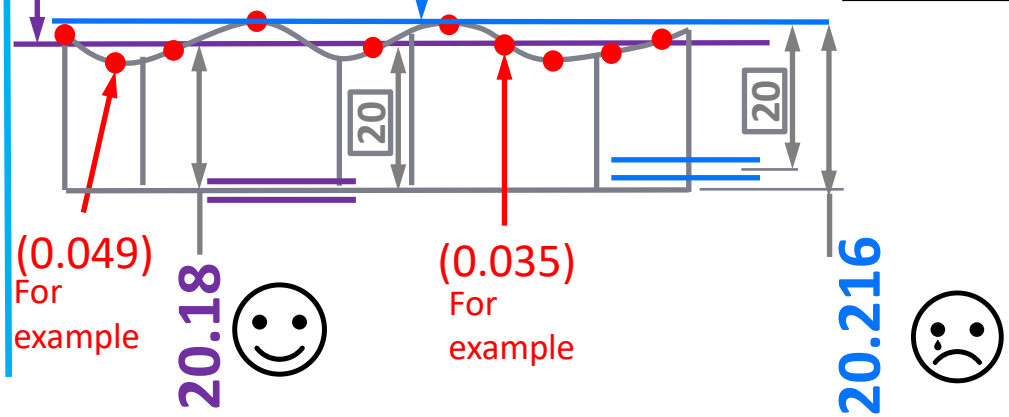
Cmm **Average** result:

10 measurement points were taken

On drawing



Means this



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$\tilde{x}$-indicators		Least squares root
Average	0.0331	0.01683
mid-range	0.029	0.01732
Median	0.04	0.01819
Most frequent value	0.049	0.02315

THANK YOU, QUESTIONS?

RONEN KOMERIAN