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```
mirror_mod = modifier_ob.modifiers.new("MIRROR_X")
mirror_mod.use_x = True
mirror_mod.use_y = False
mirror_mod.use_z = False
selection = "MIRROR_X":
mirror_mod.use_x = False
mirror_mod.use_y = True
mirror_mod.use_z = False
selection = "MIRROR_Y":
mirror_mod.use_x = False
mirror_mod.use_y = True
mirror_mod.use_z = False
selection = "MIRROR_Z":
mirror_mod.use_x = False
mirror_mod.use_y = False
mirror_mod.use_z = True

selection at the end -add back the deselected
mirror_ob.select= 1
mirror_ob.select=1
context.scene.objects.active = modifier_ob
"selected" + str(modifier_ob)) # modifier ob
mirror_ob.select = 0
key.context.selected_objects[0]
objects[one.name].select = 1

print("please select exactly two objects,")

OPERATOR CLASSES -----

types.Operator):
mirror to the selected object"
mirror_mirror_x"
```

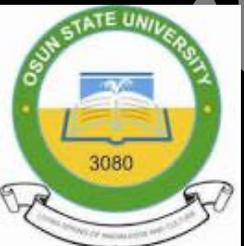
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# STATISTICAL QUALITY CONTROL WITH APPLICATIONS IN R

# Today's Highlights

- **Brief Intro on Statistical Quality Control**
- **SPC Tools:**
  - (a) **Control Chart**
  - (b) **Run Chart Analysis**
  - (c) **Pareto Chart**
  - (d) **Histogram**
  - (e) **Cause-and-Effect Diagram**
  - (f) **Tally Sheet (Check Sheet)**
  - (g) **Stratification Chart**

All these shall be done with the use of R statistical software package



# BRIEF ABOUT STATISTICAL QUALITY CONTROL

## Some Definitions:

Statistical quality control can simply be defined as an economic and effective system of maintaining and improving the quality of outputs throughout the whole operating process of specification, production and inspection based on continuous testing with random samples.



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# BRIEF ABOUT STATISTICAL QUALITY CONTROL

## Some Definitions (Cont'd):

Statistical quality control is the use of statistical methods to measure and improve the quality of manufacturing processes and products. The term "statistical process control" is often used interchangeably as its synonym.



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# BRIEF ABOUT STATISTICAL QUALITY CONTROL

Statistical quality control, the use of statistical methods in the monitoring and maintaining of the quality of products and services. One method, referred to as acceptance sampling, can be used when a decision must be made to accept or reject a group of parts or items based on the quality found in a sample. A second method, referred to as statistical process control, uses graphical displays known as control charts to determine whether a process should be continued or should be adjusted to achieve the desired quality.



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# BRIEF ABOUT STATISTICAL QUALITY CONTROL

On the other hand, Statistical process control uses sampling and statistical methods to monitor the quality of an ongoing process such as a production operation. A graphical display referred to as a control chart provides a basis for deciding whether the variation in the output of a process is due to common causes (randomly occurring variations) or due to out-of-the-ordinary assignable causes. Whenever assignable causes are identified, a decision can be made to adjust the process in order to bring the output back to acceptable quality levels.



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# BRIEF ABOUT STATISTICAL QUALITY CONTROL

Control charts can be classified by the type of data they contain. For instance, an x-bar chart is employed in situations where a sample mean is used to measure the quality of the output. Quantitative data such as length, weight, and temperature can be monitored with an x-bar chart. Process variability can be monitored using a range or R-chart. In cases in which the quality of output is measured in terms of the number of defectives or the proportion of defectives in the sample, an np-chart or a p-chart can be used.



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# BRIEF ABOUT STATISTICAL QUALITY CONTROL

All control charts are constructed in a similar fashion. For example, the centre line of an  $\bar{x}$ -bar chart corresponds to the mean of the process when the process is in control and producing output of acceptable quality. The vertical axis of the control chart identifies the scale of measurement for the variable of interest.



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# BRIEF ABOUT STATISTICAL QUALITY CONTROL

The upper horizontal line of the control chart, referred to as the upper control limit, and the lower horizontal line, referred to as the lower control limit, are chosen so that when the process is in control there will be a high probability that the value of a sample mean will fall between the two control limits. Standard practice is to set the control limits at three standard deviations above and below the process mean.



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# SPC Tools

## **CONTROL CHART**

Install the following package:

```
install.packages("qcc")
```

After the installation, then call for the library as follows:

```
library(qcc)
```

**NB: Inside the qcc library, we have a data set called "pistonrings" and within that we have diameter data set. So, we can recall the datasets as follows:**

```
data(pistonrings)
```

```
View(pistonrings)
```

The data set. The result is shown in the next slide:

# SPC Tools

Now, we can extract the variabe called diameter as follws:

```
diameter = with(pistonrings, qcc.groups(diameter, sample))
```

Run the following codes as well:

```
head(diameter)
```

```
[,1] [,2] [,3] [,4] [,5]
1 74.030 74.002 74.019 73.992 74.008
2 73.995 73.992 74.001 74.011 74.004
3 73.988 74.024 74.021 74.005 74.002
4 74.002 73.996 73.993 74.015 74.009
5 73.992 74.007 74.015 73.989 74.014
6 74.009 73.994 73.997 73.985 73.993
```

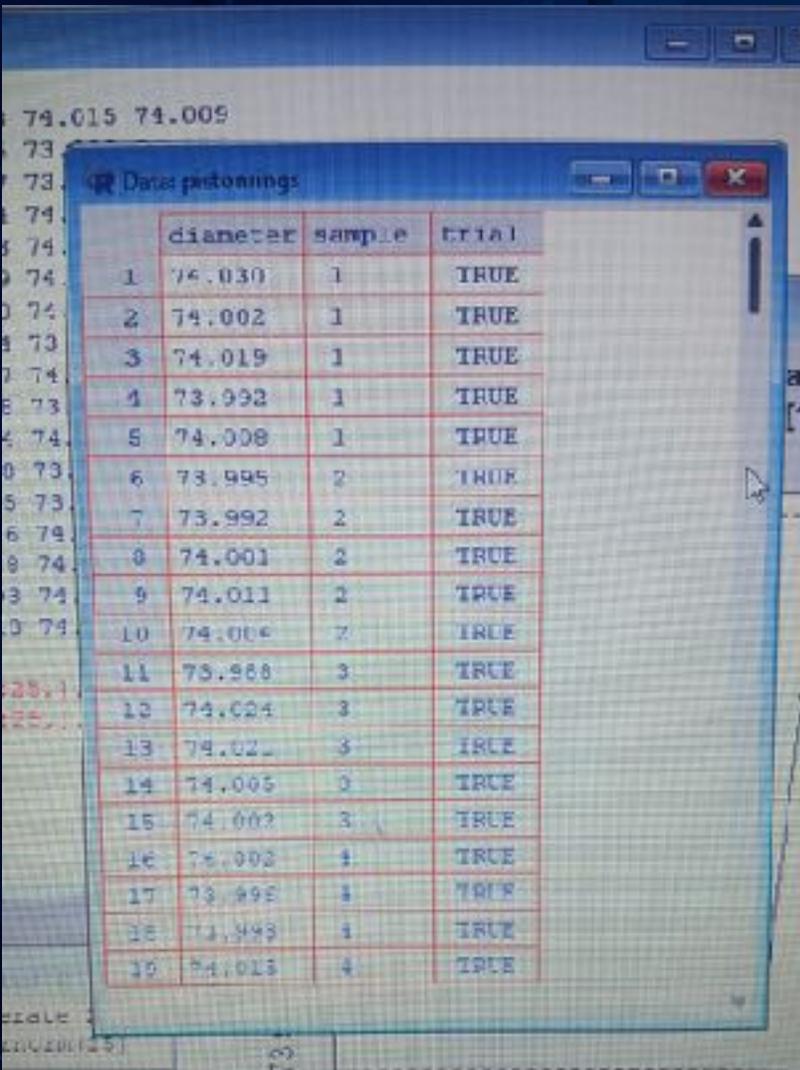
To plot the xbar chart, use the following commands:

```
q1 = qcc(diameter[1:25, ], type="xbar")
```

The x-bar plot for the first 25 datapoints are shown in the next slide

## CONTROL CHART

The data set called pistonrings:

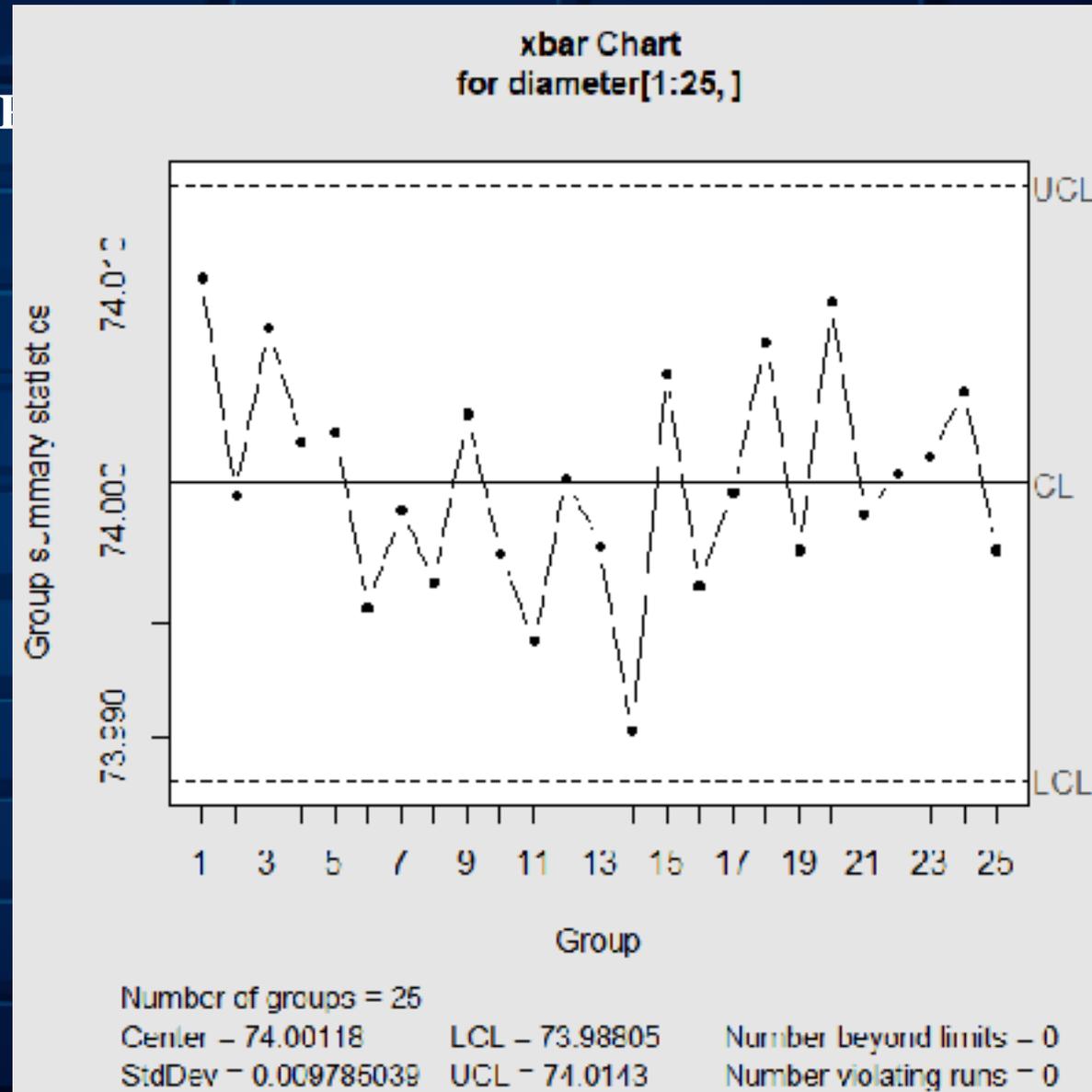


	diameter	sample	trial
1	74.030	1	TRUE
2	74.002	1	TRUE
3	74.019	1	TRUE
4	73.992	1	TRUE
5	74.008	1	TRUE
6	73.995	2	TRUE
7	73.992	2	TRUE
8	74.001	2	TRUE
9	74.011	2	TRUE
10	74.004	2	TRUE
11	73.988	3	TRUE
12	74.024	3	TRUE
13	74.021	3	TRUE
14	74.005	3	TRUE
15	74.002	3	TRUE
16	74.002	4	TRUE
17	73.992	4	TRUE
18	73.993	4	TRUE
19	74.013	4	TRUE

# SPC Tools

**CONTROL CHART**

**X-BAR CHART** (SHOWN HERE)



# SPC Tools

## **XBAR CHART**

There is no warning here; if you look at this graph very well, you will realize that the process is in control. When we have the next graph, you will see the warning line; R will give such warning line itself for us to identify it.

Kindly study the graph very well, one will see that we have only used 1 to 25 datasets, not all the 40 datasets as contained ...

Look at the next command below:

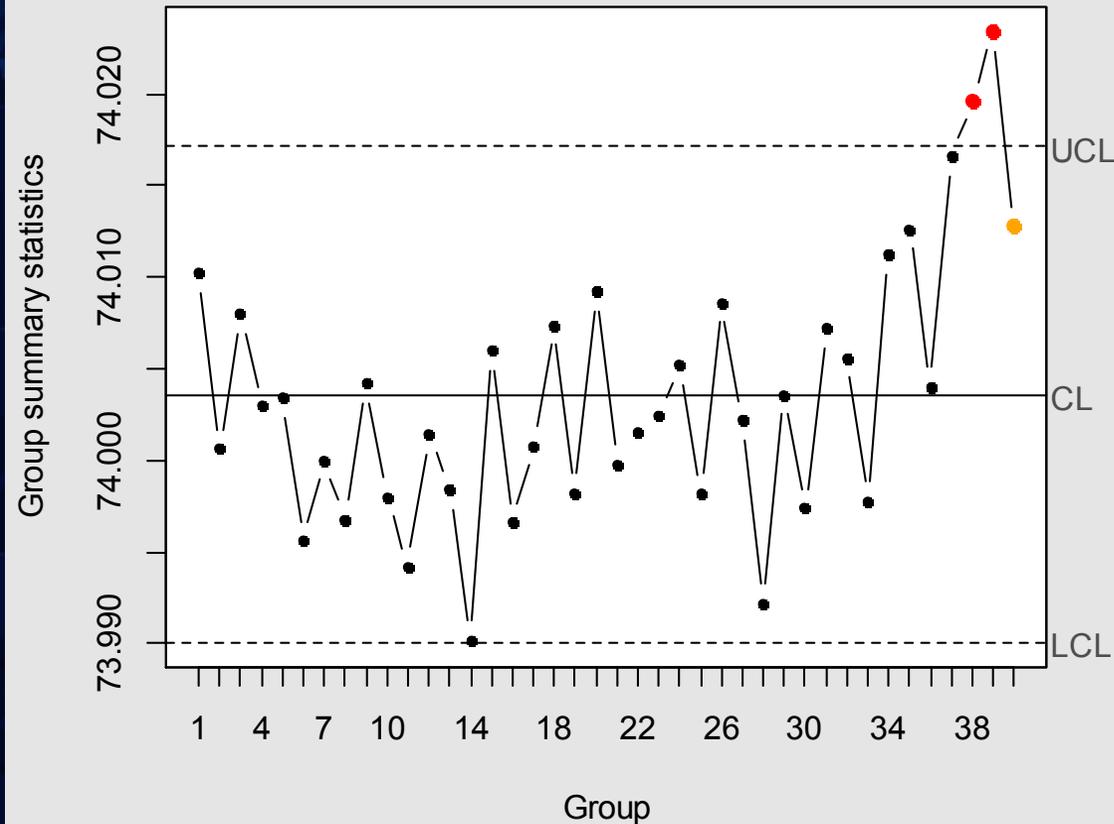
```
q2 = qcc(diameter[1:40, ], type="xbar")
```

Below is the output graphics for the q2 command.

# SPC Tools

## XBAR CHART

xbar Chart  
for diameter[1:40, ]



Number of groups = 40

Center = 74.0036

StdDev = 0.01007094

LCL = 73.99009

UCL = 74.01712

Number beyond limits = 2

Number violating runs = 1

```
q2 = qcc(diameter[1:40, ], type="xbar")
```

Now, you can see the difference such that the second xbar chart shows that the process is out of control ...

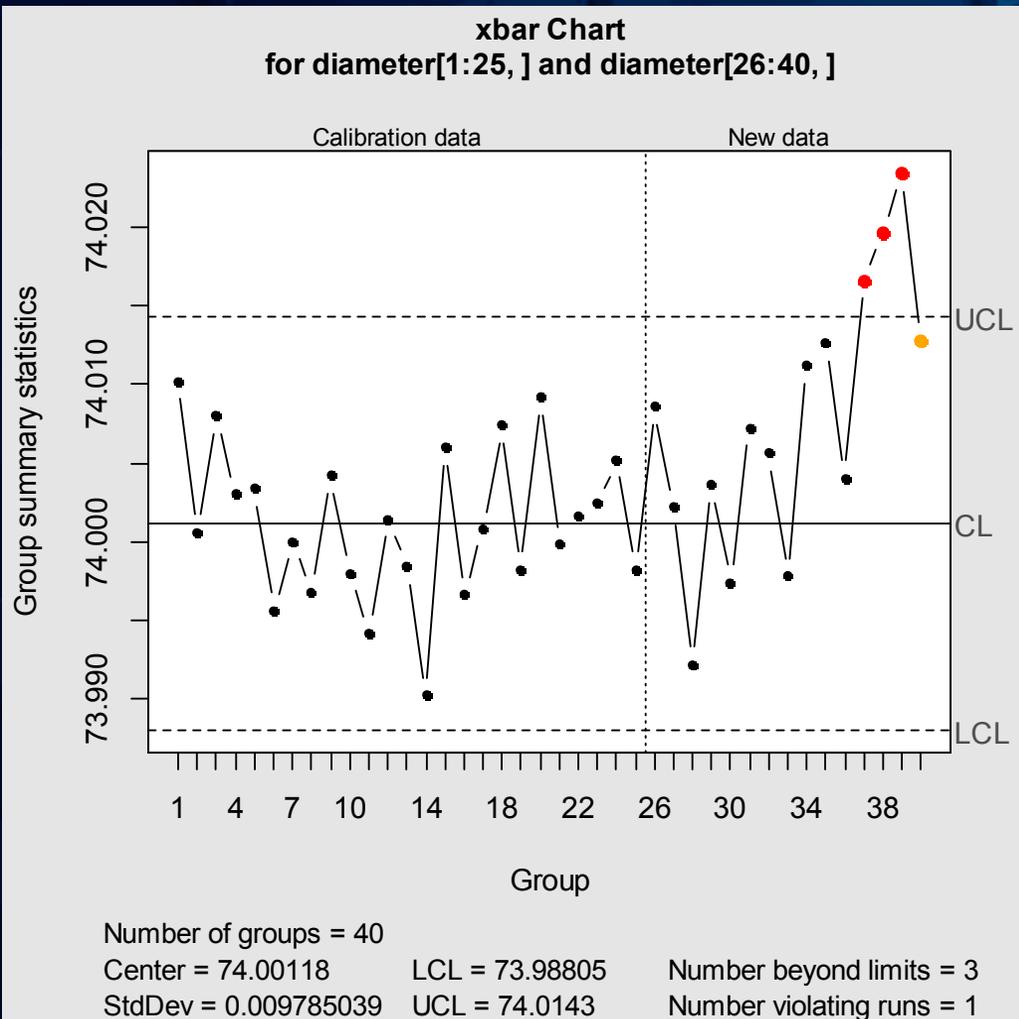
Some questions may arise here ...

- At what point?
- How does it behave?
- And so on...

# SPC Tools

## XBAR CHART

```
q3 = qcc(diameter[1:25,], type="xbar", newdata=diameter[26:40, ])
```



Look at this again....

Hope you can observe some manipulations here ....It is crystal clear that .....

# SPC Tools

If we need some summary statistics, let us run the following codes:

**summary(q1)**

See the results for summary(q1) below:

Call:

```
qcc(data = diameter[1:25, ], type = "xbar")
```

```
xbar chart for diameter[1:25, ]
```

Summary of group statistics:

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
73.99020	73.99820	74.00080	74.00118	74.00420	74.01020

Group sample size: 5

Number of groups: 25

Center of group statistics: 74.00118

Standard deviation: 0.009785039

Control limits:

LCL	UCL
73.98805	74.0143

# SPC Tools

If we need some summary statistics, let us run the following codes:

```
summary(q2)
```

Also, for the q3, we have ....

```
summary(q3)
```

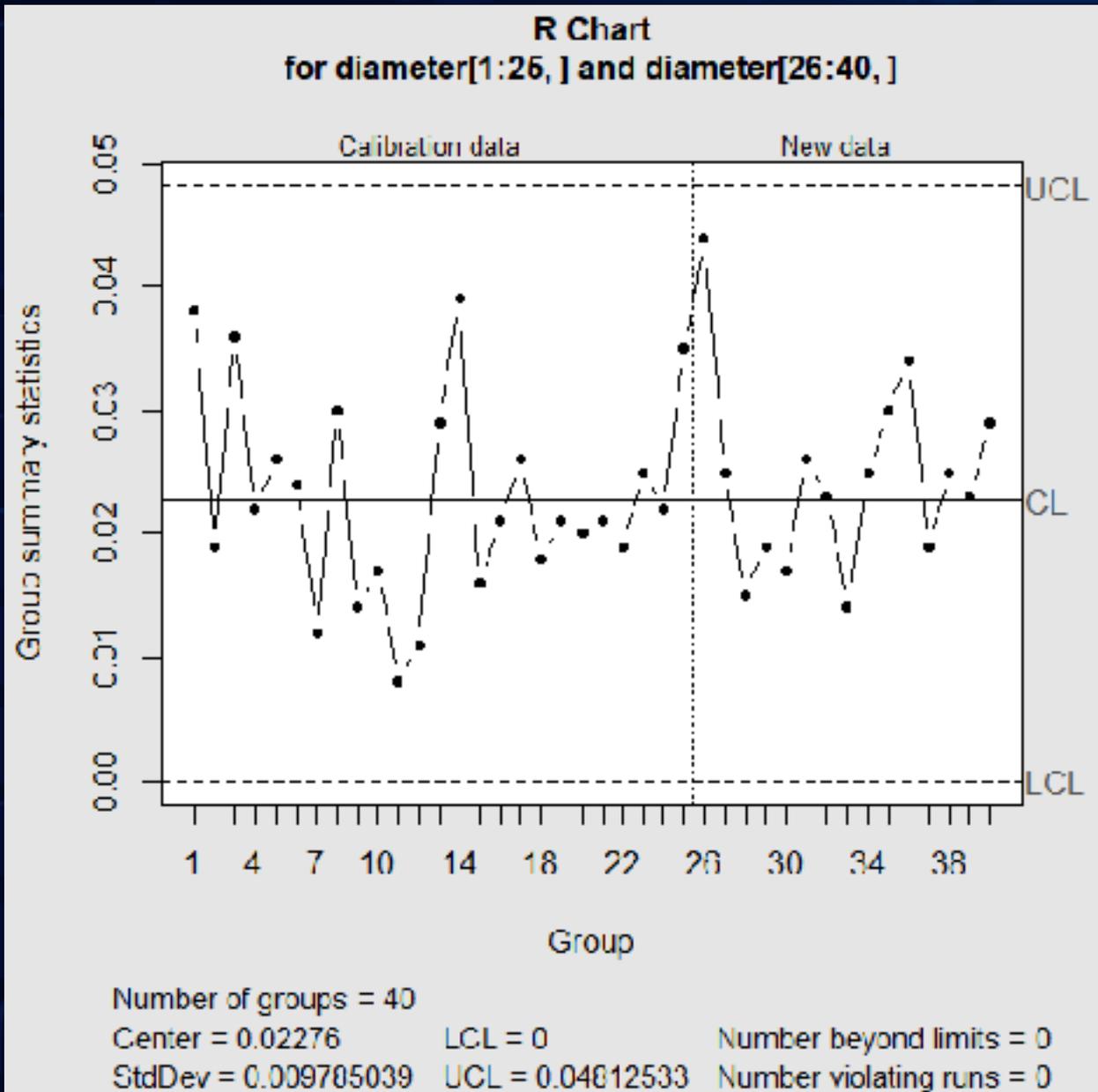
## R CHART

The command for obtaining the R Chart is given below:

```
q4 = qcc(diameter[1:25, ], type="R", newdata=diameter[26:40,])
```

The chart appears on the next slide:

# SPC Tools



Some questions may arise on the R Chart drawn here....

- Is it under control or not?

- Why do the R Chart?

- Is it appropriate to have such chart for this dataset?

- And so on ...

# SPC Tools

## Line Chart such as a Run Chart or Time-Series Chart

Plots a line chart, the values of the variable ordered according to their order in the data frame. Usually this ordering would be an ordering according to time, which yields a run chart. The default run chart provides the index, that is, sequential position, of each value of the variable from 1 to the last value. Optionally dates can be provided so that a time-series plot is produced.

For data of one variable exhibiting little trend, the center line is provided for the generation of a run chart, plotting the values of a variable in order of occurrence over time. When the center line, the median by default, is plotted, the analyses of the number and composition of the individual runs, number of consecutive values above or below the center line, is also displayed.

# SPC Tools

## Line Chart such as a Run Chart or Time-Series Chart

### Usage

```
LineChart(x, data=d, rows=NULL, n_cat=getOption("n_cat"), type=NULL,
line_color=getOption("pt_color"), area=NULL, shape_pts=21, lab_cex=1.0, axis_cex=0.75,
axis_text_color=getOption("axis_x_text_color"), rotate_x=0, rotate_y=0, offset=.5,
xy_ticks=TRUE, line_width=1, xlab=NULL, ylab=NULL, main=NULL, sub=NULL, cex=NULL,
time_start=NULL, time_by=NULL, time_reverse=FALSE, center_line=c("default", "mean",
"median", "zero", "off"), show_runs=FALSE, eval_df=NULL, quiet=getOption("quiet"), width=6,
height=6, pdf=FALSE,
...)
```

**lc(...)**



# SPC Tools

Line Chart such as a Run Chart or Time-Series Chart

Application:

```
install.packages("lessR")
```

After the installation, then we load the library as follows:

```
library(lessR)
```

After that, let's simulate 50 random numbers from the normal distr.

```
set.seed(234)
```

```
Y = rnorm(50)
```

```
LineChart(Y)
```

# SPC Tools

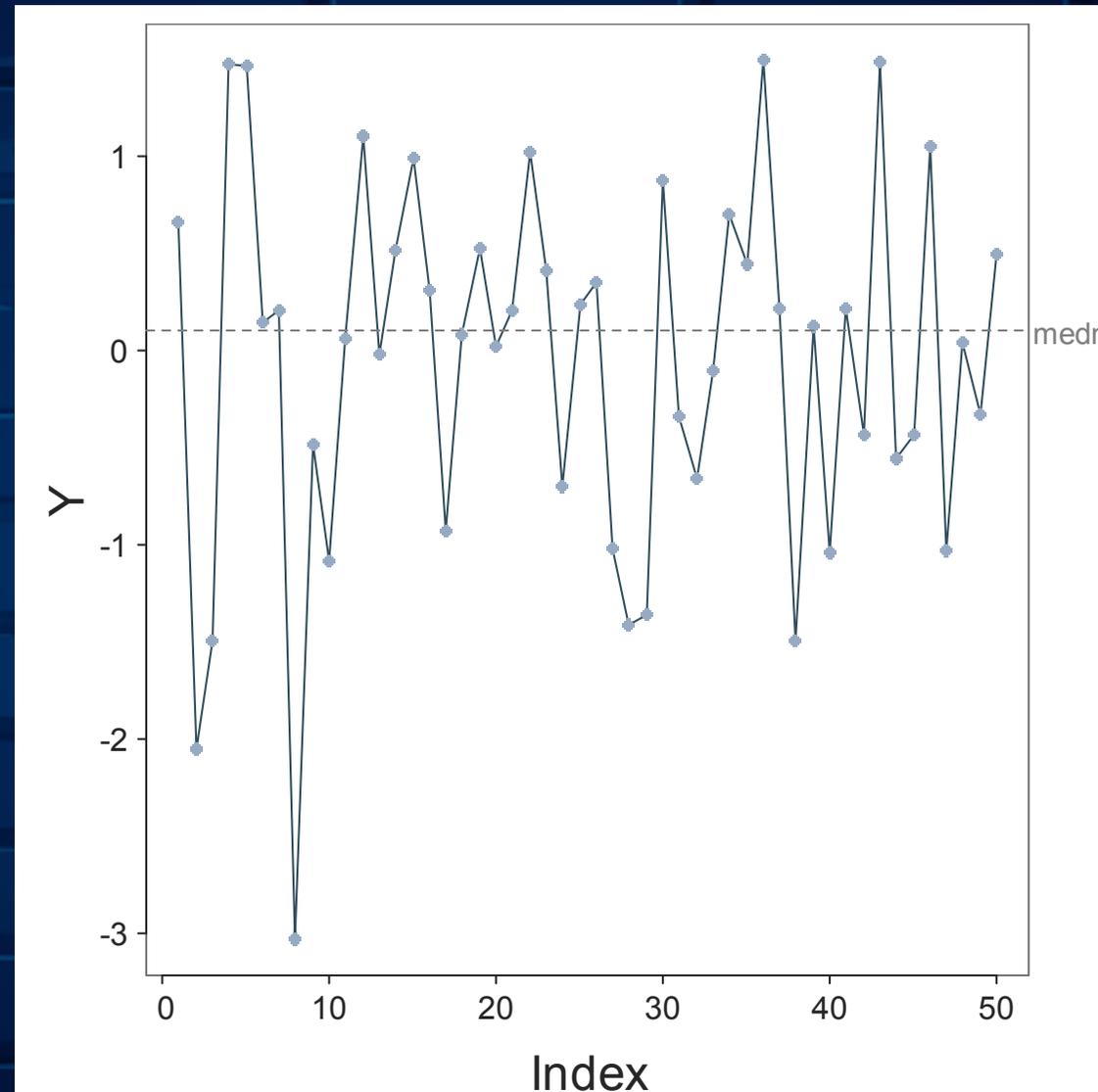
Line Chart such as a Run Chart or Time-Series Chart

This is Run Chart

The code ...

```
set.seed(234)  
Y = rnorm(50)  
LineChart(Y)
```

These produce this plot here ....





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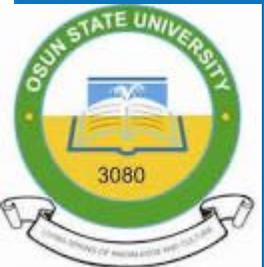
**ALL ...**

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