Control Limits for Control Charts	
Process Mean	$$\text{Control limits} = \bar{\bar{X}} \pm 3\frac{\bar{s}}{c_4\sqrt{n}}$$
Process Standard Deviation	$$\text{Control limits} = \bar{s} \pm 3\frac{c_5\,\bar{s}}{c_4}$$
Process Range	$$\text{Lower control limit} = \bar{R}D_3$$ $$\text{Upper control limit} = \bar{R}D_4$$

Process Capability Indices

	Population Known	Population Unknown
Cp	$$C_p = \frac{USL - LSL}{6\sigma}$$	$$\hat{C}_p = \frac{USL - LSL}{6s}$$
Cpk	$$C_{pk} = \min\left[\frac{USL - \mu}{3\sigma}, \frac{\mu - LSL}{3\sigma}\right]$$	$$\hat{C}_{pk} = \min\left[\frac{USL - \bar{x}}{3s}, \frac{\bar{x} - LSL}{3s}\right]$$
Cpm	$$C_{pm} = \frac{USL - LSL}{6\sqrt{\sigma^2 + (\mu - T)^2}}$$	$$\hat{C}_{pm} = \frac{USL - LSL}{6\sqrt{s^2 + (\bar{x} - T)^2}}$$

Question 1A (Theory Questions)

1. Differentiate common (or chance) causes of variation in the quality of process output from assignable (or special) causes.
2. Differentiate a stable process from an unstable process.
3. Other than applying the 3-sigma rule for detecting the presence of an assignable cause, what else do we look for when studying a control chart?
4. Describe how the output of a stable process can be improved. What actions do not improve a stable process, but rather, make the output more variable?
5. What is the purpose of maintaining control charts?
6. What is tampering in the context of process control?

Question 1b

. A normally distributed quality characteristic is monitored through the use of an $\bar{X}$/R chart. These charts have the following parameters. Both charts are in control.

	LCL	Centre Line	UCL
$\bar{X}$-Chart:	614.0	620.0	626.0
R-Chart:	0	8.236	18.795

(i) What sample size is being used?

(ii) Estimate the standard deviation of the process.

(iii) Compute the control limits for the process standard deviation chart.

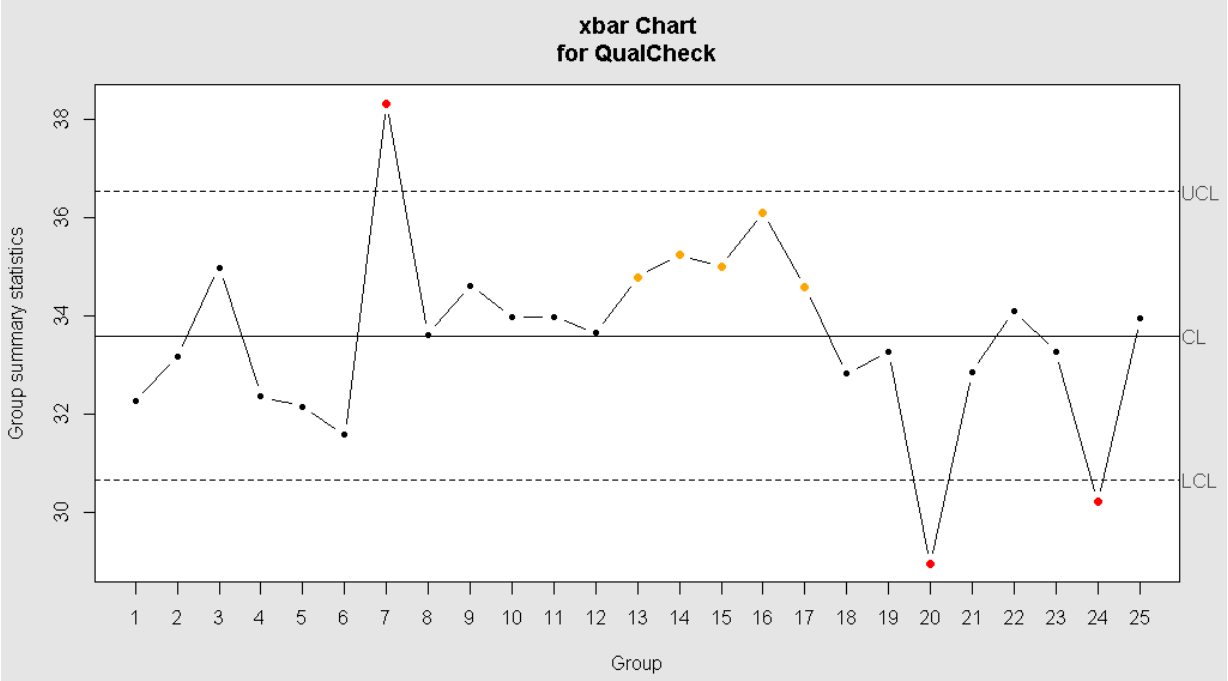
Question 2

For the following x.bar chart, compute the control limits given that the following information

Number of groups = 25
Center = 33.5944
StdDev = 2.184007

Sample size =5

Comment on the chart, with reference to two separate tests. Is the process on control?

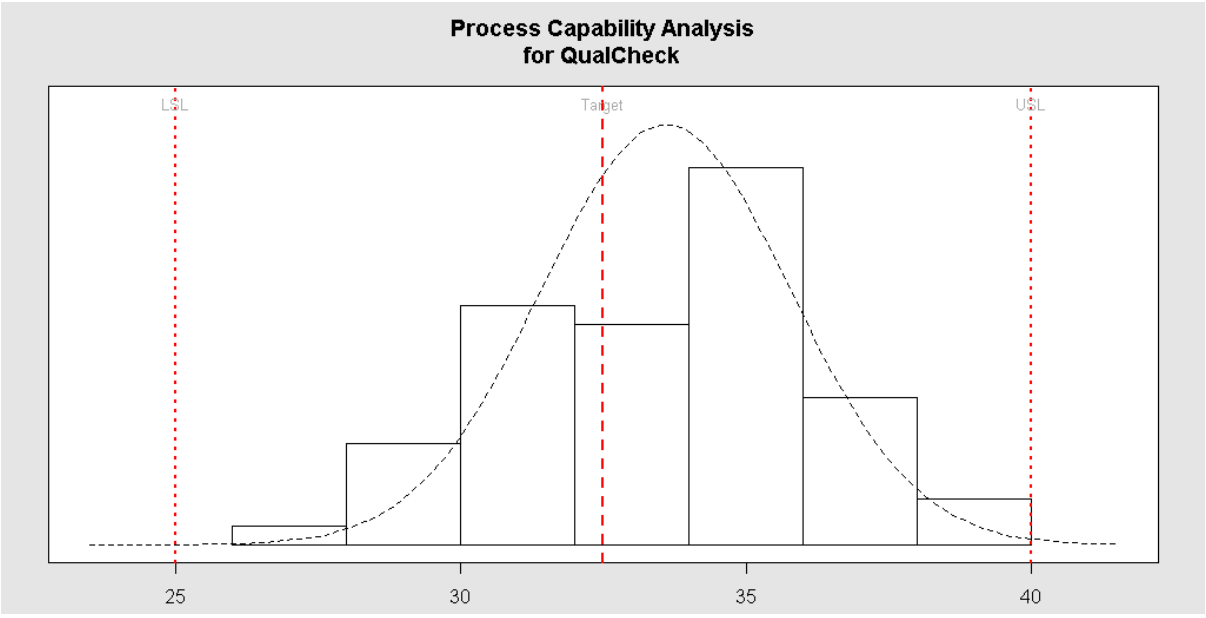


Question 3A

Suppose the specifications for the process state that the Lower and Upper Specification Levels are 25 and 40 respectively.

Determine the Process Capability Indices ***Cp*** and ***Cpk*** , commenting on the respective values.

Comment on the graphical output of the Process Capability Analysis.



(c) Is the process capable? Give reasons. **4**

(d) Calculate the ARL i.e. average run length for a change of + 0.5 mm in the average. In words give a practical interpretation of the ARL. **4**

(e) What is a CUSUM chart ? What type of departures from the production target value is this type of chart useful for detecting? Explain how it works. **4**

Question 3B

Suppose the specifications for the process state that the Lower and Upper Specification Levels are 30 and 36 respectively. Again determine the Process Capability Indices ***Cp*** and ***Cpk ,***commenting on the respective values.

Comment on the graphical output of the Process Capability Analysis.