Indian Statistical Institute, Bangalore
MS (QMS) First Year
First Semester - Statistical Process Control I

Midterm Exam — Date: September13, 2019
Maximum marks: 50 — Duration: 2 hours

Answer as many questions as you can. The maximum you can score is 50

1. Check whether the following statements are true or false. Justify your answers in not more than 3 sentences. [10]

   a. The central limit theorem plays an important role in setting up of $\bar{x}$ control chart limits.
   b. If 3σ limits in a control chart are replaced by 4σ limits, then one needs to investigate for assignable causes even when assignable causes are not present in the process.
   c. For monitoring attribute characteristic, one needs to monitor both measures of central tendency and dispersion in separate control charts.
   d. The individual and moving range control chart are used to monitor the hardness achieved in a heat-treatment process. If the upper control limit of the moving range chart is 10.5, then the estimated process standard deviation will be 2.85.
   e. The quality of a call handling process is monitored using a p-chart with $\bar{p}$ = 0.02. Out of 120 calls monitored in an hour, 5 calls are found to be defectives. This is an indication that the call handling process is out of control during that hour.

2. Briefly explain the following: [10]
   a. Chance and assignable causes of variation
   b. Rational subgrouping

3. A TiW layer is deposited on a substrate using a sputtering tool. The layer thickness measurements (in Angstroms) of 20 substrates are given below: [20]

SL No	Thickness	SL No	Thickness
1	448	11	447
2	441	12	451
3	447	13	448
4	455	14	449
5	449	15	452
6	453	16	445
7	447	17	454
8	450	18	435
9	446	19	451
10	450	20	452

a. Check whether the layer thickness is normally distributed using the normal probability plot method?
b. Using individual and moving range (I-MR) charts, check whether the process is in control? If not, assume assignable causes can be found, out-of-control points can be eliminated and revise the control limits? Construct the control chart and plot the in-control process data?
c. Estimate the process mean and standard deviation for the in-control process using I-MR charts?
d. If the specification limits on layer thickness are 450 ± 15, compute the process capability indices Cp and Cpk? What are your conclusions regarding the capability of the process to meet the customer requirement?
e. Assuming that if an item exceeds the upper specification limit it must be rejected and if it is below the lower specification limit it can be reworked, what percent rejection and rework is the process now producing?
f. If the process mean is shifted to 450, estimate the percent rejection and rework?

4. The number of nonconforming counter gear subassemblies in samples of size 200 is given below. [15]

Sample	Number nonconforming	Sample	Number nonconforming
1	7	11	6
2	4	12	15
3	1	13	0
4	3	14	9
5	10	15	5
6	6	16	1
7	8	17	4
8	5	18	5
9	2	19	12
10	7	20	7

a. Using all the data, construct a number nonconforming control chart?

b. Determine whether the process is in statistical control? If not, assume assignable causes can be found, out-of-control points can be eliminated and revise the control chart? Construct the control chart and plot the in-control process data?