10.5

Q1 (10.5 marks/0.75 pt) Please state whether each of the following statements is True/False, and please correct the false part:

- For variable sample sizes, the proper variable control charts are **I-R** charts. (F) $\bar{x}$-S
- The **defect concentration diagram** is analyzed to determine whether the location of the defects on the unit conveys any useful information about the potential causes of the defects. True
- For a process that uses an automatic inspection of each unit, **use x-bar and R charts**. (F) I-MR
- A point will plot outside the control limits on both the individual chart and the moving range chart. It is most likely an indication that the **mean is out of control**. True
- **Cycle pattern** is indicated when the plotted points tend to fall near or slightly outside the control limits, with relatively few points near the centerline. (F) Mixture
- **Shift patterns** are usually due to a gradual wearing out or deterioration of a tool. (F) trend
- **Value stream mapping** is a flowchart or text-based description of the sequence of activities that must take place following the occurrence of an activating event. (F) out-of-control-action plan (OCAP)
- The control limits are driven by the **chance variability** of the process. (True)
- If per-unit inspection and testing costs are not excessive, high-speed production processes are often monitored with moderately **large sample sizes more frequently**. True
- **Control chart** mean the chance of differences between subgroups will be maximized. (F) rational subgroup concept
- The lower control limit of the MR chart is always **non-zero**. (F) zero
- The 3-sigma control limits are called the **warning limits**. (F) action limits
- The control charts only detect **key** causes. assignable (F)
- The **Scatter diagram** is used to display the relationship between two variables. True

6

Q2 (19.5 marks) Please answer the following questions (show calculations):

- The time to failure is well-modeled as Gamma with a scale of 0.02 and a mean time to failure of 100. The shape parameter = 2 (1.5 marks

λ $\mu = 100$

$$\mu = \frac{r}{\lambda}, \quad r = (100) * 0.02 = 2$$

- The time to failure of a product is well-modeled as Exponential with a mean time to failure of 200. The probability of a product failing before 200 hours = 0.63212 (1.5 marks

$\mu = 200$

$\lambda = \frac{1}{200}$

$$F(200) = 1 - e^{-\frac{200}{200}} = 0.63212$$

- The time to failure of a product is well-modeled as a Weibull distribution with shape and scale of 0.25 and 100 hours, respectively. The mean time to failure = 24.00 (1.5 marks

$0.25 = \beta$

$\theta = 100 = \lambda$

$$\mu = 100 * \left(\frac{1}{0.25}\right)! = 2400$$

- The estimated center line of the s chart = 20, then the process standard deviation (n = 9) = 20.63 (1.5 marks)

$$\bar{S} = 20, \quad \hat{\sigma} = \frac{20}{c_4} = \frac{20}{0.9693} = 20.63$$

13.5

$\bar{R} = 15$ $\quad 15 = \sigma \times 2.326$

- The center line of the R chart = 15. Assuming the standard deviation is known, then the process standard deviation (n= 5) = 6.4488 (1.5 marks)

$$\sigma = \frac{15}{2.326} = 6.4488$$

$\bar{\bar{x}} = 85 \rightarrow \bar{s} = 9$, $\hat{\sigma} = 9.574$, $\hat{\sigma} = \frac{\bar{R}}{d_2} \rightarrow \bar{R} = 22.27$

- The estimated centerlines of the x-bar and s charts (n=5) are 85 and 9, respectively. The corresponding LCL of the x-bar chart using the x-bar and R (n=5) charts is ---------------(1.5 marks)

$$LCL = \bar{\bar{X}} - L\left(\frac{\bar{R}}{\sqrt{n}\, d_2}\right) = 85 - 0.577(22.27) = 72.15$$

- The estimated centerlines of the x-bar and R charts (n=9) are 120 and 9, respectively. The 4-sigma UCL of the x-bar chart is 124.04 (1.5 marks)

$$UCL = 120 + 4\left(\frac{9}{\sqrt{9}\,(2.97)}\right) = 124.04$$

6

- Based on standard values, the centerlines of the x-bar and R charts (n=5) are 130 and 18, respectively. The UCL of the R chart is ---------------(1.5 marks)

$\sigma d_2 = 18$ $\quad \sigma = 7.7386$

$$UCL = D_2(\sigma) = 4.918(7.7386)$$

$$UCL = 38.058$$

- **Specifications of the important QCH** are *at most* 635. The $\bar{x}$ -R charts were used (n = 9), where the estimated CL and LCL of the $\bar{x}$ chart were found 627 and 600, respectively. (5 marks)
  - The estimated process standard deviation = 27 (1.5 marks)

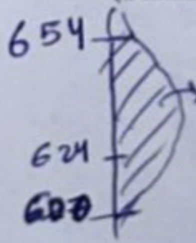
    $CL - LCL = 3\frac{\hat{\sigma}}{\sqrt{3}} \rightarrow \hat{\sigma} = 27$

  - The upper natural tolerance limit = 708 (1.5 marks)

    $627 + 3(27) = 708$

5

  - Suppose that the process mean shifts to 624. The probability of not detecting the shift by the first sample = 0.99578 ----(2 marks)



$$\beta = \Phi\left(\frac{654-624}{27/\sqrt{9}}\right) - \Phi\left(\frac{600-600}{27/\sqrt{9}}\right) = \Phi(3.33) - \Phi(-2.67)$$

$$= 0.99578$$

$(x \geq 35)$

- **The specifications of the important** QCH are at least 35. The $\bar{x}$ -s charts were used (n = 4). (2.5 marks)

Given $\sum_{i=1}^{25} \bar{x}_i = 1000$, $\sum_{i=1}^{25} R_i = 120$ $\quad$ The fraction nonconforming = ---------------

$\hat{\mu} = \frac{1000}{25} = 40$

$\bar{R} = 4.8$

$\hat{\sigma} = 2.33$

$\bar{S} = 2.148$

$$F(\text{non con}) = \Phi\left(\frac{35-40}{2.33}\right) = \Phi(-2.145) = 0.01618$$

2.5