RE30003
Exercise Problems

Q1

In a printing company, data from the previous month show the following types of errors, with the unit cost (in dollars) of rectifying each error, in Table

(a) Construct a Pareto chart and discuss the results.

(b) If management has a monthly allocation of $18,000, which areas should they tackle?

Error Categories	Frequency	Unit Costs
Typographical	4000	0.20
Proofreading	3500	0.50
Paper tension	80	50.00
Paper misalignment	100	30.00
Inadequate binding	120	100.00

Q2

The guidance system design of a satellite places several components in parallel. The system will function as long as at least one of the components is operational. In a particular satellite, 4 such components are placed in parallel. If the probability of a component operating successfully is 0.9, what is the probability of the system functioning? What is the probability of the system failing? Assume that the components operate independently of each other.

Q3

The outside diameter of a part used in a gear assembly is known to be normally distributed with a mean of 40 mm and standard deviation of 2.5 mm. The specifications on the diameter are (36, 45), which means that part diameters between 36 and 45 mm are considered acceptable. The unit cost of rework is \$0.20, while the unit cost of scrap is \$0.50. If the daily production rate is 2000, what is the expected total daily cost of rework and scrap?

Q4

The breaking strength of a cable is known to be normally distributed with a mean of 4000 kg and a standard deviation of 25 kg. The manufacturer prefers that at least 95% of its product meet a strength requirement of 4050 kg. Is this requirement being met? If not, by changing the process parameter, what should the process mean target value be?

Q5

The specifications for the thickness of nonferrous washers are 1.0 ± 0.04 mm. From process data, the distribution of the washer thickness is estimated to be normal with a mean of 0.98 mm and a standard deviation of 0.02 mm. The unit cost of rework is \$0.10, and the unit cost of scrap is \$0.15. For a daily production of 10,000 items:

(a) What proportion of the washers is conforming? What is the expected total daily cost of rework and scrap?

(b) In its study of constant improvement, the manufacturer changes the mean setting of the machine to 1.0 mm. If the standard deviation is the same as before, what is the expected total daily cost of rework and scrap?

(c) The manufacturer is trying to improve the process and reduces its standard deviation to 0.015 mm. If the process mean is maintained at 1.0 mm, what is the percent decrease in the expected total daily cost of rework and scrap compared to that of part (a)?

Q6

A component is known to have an exponential time-to-failure distribution with a mean life of 10,000 hours.

(a) What is the probability of the component lasting at least 8000 hours?

(b) If the component is in operation at 9000 hours, what is the probability that it will last another 6000 hours?

(c) Two such components are put in parallel, so that the system will be in operation if at least one of the components is operational. What is the probability of the system being operational for 12,000 hours? Assume that the components operate independently.

Q7

For three-sigma control limits, what is the probability of type I error? What is the probability of 2 out of 3 consecutive points falling outside the two-sigma warning limits? What is the probability of 4 out of 5 consecutive points falling outside the one-sigma limits?

Q8

The diameter of a part produced by an automatic machine is a characteristic of interest. Based on historical data, the process average diameter is 15 mm with a process standard deviation of 0.8 mm. If samples of size 4 are randomly selected from the process:

(a) Find the 1σ and 2σ control limits.

(b) Find the 3σ control limits for the average diameter.

(c) What is the probability of a false alarm?

(d) If the process mean shifts to 14.5 mm, what is the probability of not detecting this shift on the first sample plotted after the shift? What is the ARL?

(e) What is the probability of failing to detect the shift by the second sample plotted after the shift?

Q9

A major automobile company is interested in reducing the time that customers have to wait while having their car serviced with one of the dealers. They select four customers randomly each day and find the total time that each customer has to wait (in minutes) while his or her car is serviced. From these four observations, the sample average and range are found. This process is repeated for 25 days. The summary data for these observations are

$$\sum_{i=1}^{25} \overline{X}_i = 1000, \qquad \sum_{i=1}^{25} R_i = 250$$

(a) Find the $\overline{X}$- and R-chart control limits

(b) Assuming that the process is in control and the distribution of waiting time is normal, find the percentage of customers who will not have to wait more than 50 minutes.

(c) Find the 2σ control limits. (for X-bar chart)

(d) The service manager is developing a promotional program and is interested in reducing the average waiting time to 30 minutes by employing more mechanics. If the plan is successful, what proportion of the customers will have to wait more than 40 minutes? More than 50 minutes?

Q10

The baking time of painted corrugated sheet metal is of interest. Too much time will cause the paint to flake, and too little time will result in an unacceptable finish. The specifications on baking time are 10 ± 0.2 minutes. Random samples of size 6 are selected and their baking times noted. The sample means and standard deviations are calculated for 20 samples with the following results:

$$\sum_{i=1}^{20} \overline{X}_i = 199.8, \qquad \sum_{i=1}^{20} s_i = 1.40$$

(a) Calculate the centerline and control limits for the $\overline{X}$- and s-charts.
(b) Estimate the process mean and standard deviation, assuming the process to be in control.
(c) Is the process capable? What proportion of the output is nonconforming?
(d) If the mean of the process can be shifted to 10 minutes, would you recommend such a change?
(e) If the process mean changes to 10.2 minutes, what is the probability of detecting this change on the first sample taken after the shift? Assume that the process variability has not changed.

Q11

A building contractor subcontracts to a local merchant a job involving hanging wallpaper. To have an idea of the quality level of the merchant's work, the contractor randomly selects 300 m^2 and counts the number of blemishes. The total number of blemishes for 30 samples is 80. Construct the centerline and control limits for an appropriate chart. Is it reasonable for the contractor to set a goal of an average of 0.5 blemish per 100 m^2?

Q12

A pharmaceutical company producing vitamin capsules desires a proportion of calcium content between 40 and 55 ppm. A random sample of 20 capsules chosen from the output yields a sample mean calcium content of 44 ppm with a standard deviation of 3 ppm. Find the natural tolerance limits of the process. If the process is in control at the present values of its parameters, what proportion of the output will be nonconforming, assuming a normal distribution of the characteristic?

Q13

For Exercise Q12, find the C_p index. Comment on the ability of the process to meet specifications. What proportion of the specification range is used up by the process? If it is easier to change the process mean than to change its variability, to what value should the process mean be set to minimize the proportion of nonconforming product?

Q14

Cause and Effect Diagram for Lost Packages:

Failure Modes	Causes	Severity
Sender Error	Incorrect address	High
Mail Deliverer Error	Delivered to wrong address	High
Post Office Personnel Error	Mishandle package	High
Equipment Error	Knocked out of conveyer belt	Moderate
Sender Error	Wrong zip code	Moderate
Equipment Error	Tracking failure	Moderate
Post Office Personnel Error	Placement in wrong bin for sorting	Low
Mail Deliverer Error	Package lost	Low
Equipment Error	Barcode reading error	Low
Mail Deliverer Error	Improper storage in delivery van	Low

Thank you!