

## PROBLEMS

- Specifications for a part for a 3-D printer state that the part should weigh between 24 and 25 ounces. The process that produces the parts has a mean of 24.5 ounces and a standard deviation of .2 ounce. The distribution of output is normal.
  - What percentage of parts will not meet the weight specs?
  - Within what values will 95.44 percent of the sample means of this process fall if samples of  $n = 16$  are taken and the process is in control (random)?
  - Using the control limits from part *b*, would the following sample means be in control? 24.52, 24.53, 24.44, 24.51, 24.41, 24.39
- An automatic filling machine is used to fill 1-liter bottles of cola. The machine's output is approximately normal with a mean of 1.0 liter and a standard deviation of .01 liter. Output is monitored using means of samples of 25 observations.
  - Determine upper and lower control limits that will include roughly 97 percent of the sample means when the process is in control.
  - Given the following sample means—1.005, 1.001, .998, 1.002, .995, and .999—is the process in control?
  - Is the process in control given the following sample means—1.003, .999, .997, 1.001, 1.002, .998, and 1.004?
- The time in minutes to replace vehicle wiper blades at a service center was monitored using a mean and a range chart. Six samples of  $n = 20$  observations were obtained and the sample means and ranges were computed:

Sample	Mean	Range	Sample	Mean	Range
1	3.06	.42	4	3.13	.46
2	3.15	.50	5	3.06	.46
3	3.11	.41	6	3.09	.45

- Using the factors in Table 10.3, determine upper and lower limits for mean and range charts. Is the process within the control limits?
- The time in minutes needed to assemble security cameras at a production facility was recorded for eight samples of 15 observations each, and means and ranges were computed. Using factors from Table 10.3, compute control limits for the means and ranges to determine if the process is in control.

Sample	Mean	Range	Sample	Mean	Range
1	7.10	.52	5	7.21	.46
2	6.92	.48	6	8.01	.55
3	7.25	.50	7	7.80	.53
4	7.54	.51	8	7.63	.49

- Software upgrade times (in minutes) are being evaluated. Samples of five observations each have been taken, and the results are as listed. Using factors from Table 10.3, determine upper and lower control limits for mean and range charts, and decide if the process is in control.

SAMPLE					
1	2	3	4	5	6
79.2	80.5	79.6	78.9	80.5	79.7
78.8	78.7	79.6	79.4	79.6	80.6
80.0	81.0	80.4	79.7	80.4	80.5
78.4	80.4	80.3	79.4	80.8	80.0
81.0	80.1	80.8	80.6	78.8	81.1

- Using samples of 200 credit card statements, an auditor found the following:

Sample	1	2	3	4
Number with errors	4	2	5	9

- Determine the fraction defective in each sample.
- If the true fraction defective for this process is unknown, what is your estimate of it?
- What is your estimate of the mean and standard deviation of the sampling distribution of fractions defective for samples of this size?

- d. What control limits would give an alpha risk of .03 for this process?
  - e. What alpha risk would control limits of .047 and .003 provide?
  - f. Using control limits of .047 and .003, is the process in control?
  - g. Suppose that the long-term fraction defective of the process is known to be 2 percent. What are the values of the mean and standard deviation of the sampling distribution?
  - h. Construct a control chart for the process, assuming a fraction defective of 2 percent, using two-sigma control limits. Is the process in control?
6. A medical facility does MRIs for sports injuries. Occasionally, a test yields inconclusive results and must be repeated. Using the following sample data and  $n = 200$ , determine the upper and lower control limits for the fraction of retests using two-sigma limits. Is the process in control?

	SAMPLE												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Number of retests	1	2	2	0	2	1	2	0	2	7	3	2	1

7. The postmaster of a small western town receives a certain number of complaints each day about mail delivery. Determine three-sigma control limits using the following data. Is the process in control?

	DAY													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Number of complaints	4	10	14	8	9	6	5	12	13	7	6	4	2	10

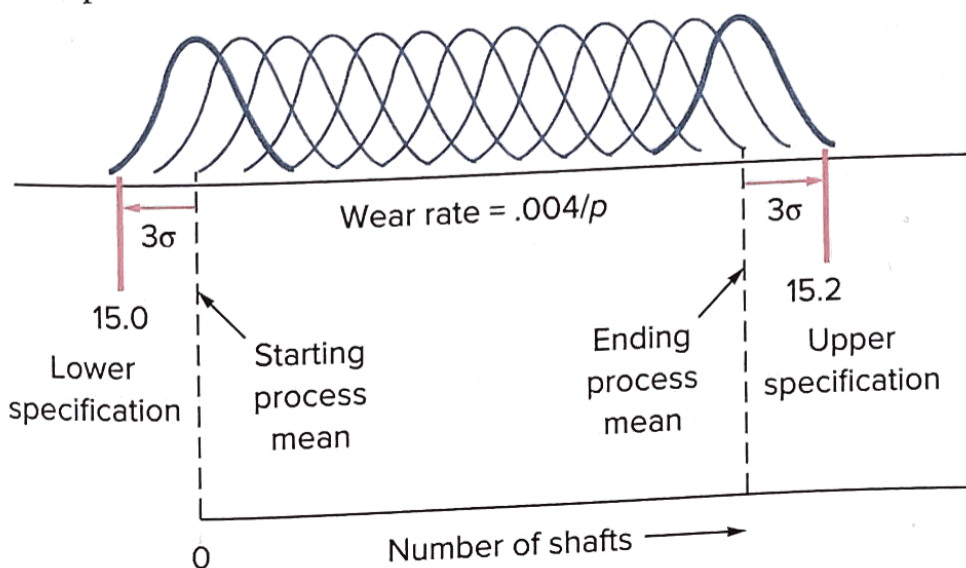
8. Given the following data for the number of defects per spool of cable, using three-sigma limits, is the process in control?

	OBSERVATION													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Number of defects	2	3	1	0	1	3	2	0	2	1	3	1	2	0

9. After a number of complaints about its tech assistance, a computer manufacturer examined samples of calls to determine the frequency of wrong advice given to callers. Each sample consisted of 100 calls. Determine 95 percent limits. Is the tech assistance process stable (i.e., in control)? Explain.

	SAMPLE															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Number of errors	5	3	5	7	4	6	8	4	5	9	3	4	5	6	6	7

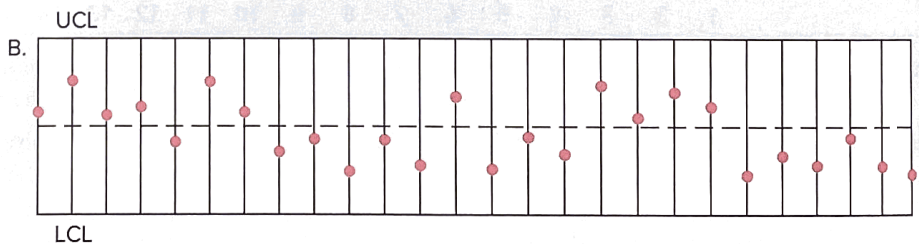
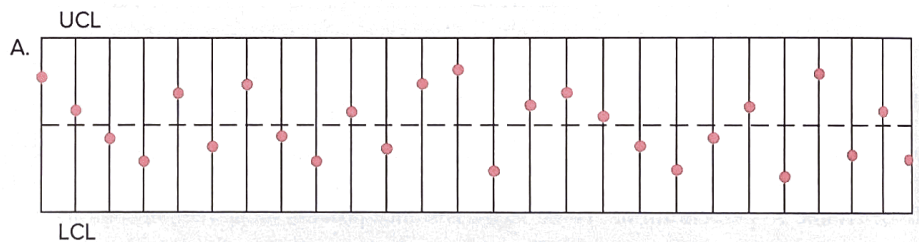
10. Specifications for a metal shaft are much wider than the machine used to make shafts is capable of. Consequently, the decision has been made to allow the cutting tool to wear a certain amount before replacement. The tool wears at the rate of .004 centimeter per piece. The process has a natural variation,  $\sigma$ , of .02 centimeter and is normally distributed. Specifications are 15.0 to 15.2 centimeters. A three-sigma cushion is set at each end to minimize the risk of output outside of the specifications. How many shafts can the process turn out before tool replacement becomes necessary? (See diagram.)



11. The lower and upper specifications for the software upgrades in Problem 4 are 78 minutes and 81 minutes. Estimate the percentage of process output that can be expected to fall within the specifications. As a manager, would you feel that the specifications are being met?
12. The time needed for checking in at a motel is to be investigated. Historically, the process has had a standard deviation equal to .146. The means of 39 samples of  $n = 14$  are shown in the following table.

Sample	Mean	Sample	Mean	Sample	Mean	Sample	Mean
1	3.86	11	3.88	21	3.84	31	3.88
2	3.90	12	3.86	22	3.82	32	3.76
3	3.83	13	3.88	23	3.89	33	3.83
4	3.81	14	3.81	24	3.86	34	3.77
5	3.84	15	3.83	25	3.88	35	3.86
6	3.83	16	3.86	26	3.90	36	3.80
7	3.87	17	3.82	27	3.81	37	3.84
8	3.88	18	3.86	28	3.86	38	3.79
9	3.84	19	3.84	29	3.98	39	3.85
10	3.80	20	3.87	30	3.96		

- a. Construct an  $\bar{x}$ -chart for this process with three-sigma limits. Is the process in control?
  - b. Analyze the data using a median run test and an up/down run test. What can you conclude?
13. For each of the accompanying control charts, analyze the data using both median and up/down run tests with  $z = \pm 1.96$  limits. Are nonrandom variations present? Assume the center line is the long-term median.



14. Analyze the data in the following problems using median and up/down run tests with  $z = \pm 2$ .
- a. Given the following run test results of process output, what do the results of the run tests suggest about the process?

Test	z-score
Median	+1.37
Up/Down	+1.05

- b. Twenty means were plotted on a control chart. An analyst counted 14 runs above/below the median, and 8 up/down runs. What do the results suggest about the process?
- c. Problem 8
- d. Problem 7