Concept Question 1.1

The objective of a statistical process control (SPC) system is to

- A. provide a statistical signal when assignable causes of variation are present.
- B. eliminate natural variations.
- C. provide a statistical signal when natural causes of variation are present.
- D. assess customer expectations.

Concept Question 1.2

Question Help

The *R*-chart

- A. is used to measure changes in the central tendency.
- B. generally uses control limits set at plus or minus 2 standard deviations of the distribution, rather than plus or minus 3 which is commonly used on the *x*-bar chart.
- C. control limits are computed using sample standard deviations.
- D. is used to indicate gains or losses in uniformity.

Concept Question 1.3

Which type of control chart should be used when it is possible to have more than one mistake per item?

- A. *R*-chart
- B. *x*-bar chart
- C. *p*-chart
- D. *c*-chart

Concept Question 1.4

A *c*-chart is based on the

- A. normal distribution.
- B. binomial distribution.
- C. Poisson distribution.
- D. Erlang distribution.

Concept Question 2.1

Process capability

- A. is assured when the process is statistically in control.
- B. means that the natural variation of the process must be small enough to produce products that meet the standard.
- C. exists only in theory; it cannot be measured.
- D. exists when C_{PK} is less than 1.0.

Concept Question 2.2

The two popular measures for quantitatively determining if a process is capable are

- ✔ A. process capability ratio and process capability index.
- B. process mean and range.
- C. process mean and standard deviation of the process population.
- D. upper specification and lower specification.

Concept Question 2.3

Which of the following measures the proportion of variation (3σ) between the center of the process and the nearest specification limit?

- A. standard deviation of the process population
- B. process capability ratio
- C. process range
- ✔ D. process capability index

Concept Question 2.4

Which of the following statements is NOT true about the process capability ratio?

- ✔ A. A capable process has a process capability ratio less than one.
- B. The process capability ratio is a ratio of the specification to the process variation.
- C. The process capability ratio is computed as the difference of the upper and lower specification limits divided by six standard deviations.
- D. The process capability ratio is a ratio for determining whether a process meets design specifications.

Concept Question 3.1

What is the percentage defective in an average lot of goods inspected through acceptance sampling?

- ✔ A. AOQ
- B. LTPD
- C. AQL
- D. OC curve

Concept Question 3.2

In acceptance sampling, the producer's risk is the risk of having a

- A. bad lot rejected.
- B. bad lot accepted.
- ✔ C. good lot rejected.
- D. good lot accepted.

Concept Question 3.3

Which is the best statement regarding an operating characteristic curve?

- ✔ A. As the AQL decreases, the producer's risk also decreases.
- B. As the fraction defective decreases, the probability of accepting the lot also decreases.
- C. As the fraction defective increases, the probability of accepting the lot also increases.
- D. As the lot tolerance percent defective decreases, the consumer's risk also decreases.

Concept Question 3.4

What is the probability of accepting a bad lot?

- ✔ A. type II error (beta)
- B. AQL
- C. type I error (alpha)
- D. LTPD

Problem 6s.1

Boxes of Honey-Nut Oatmeal are produced to contain 14.0 ounces, with a standard deviation of 0.10 ounce. For a sample size of 64, the *3-sigma* $\bar{x}$ chart control limits are:

Upper Control Limit ($UCL_{\bar{x}}$) = 14.04 ounces *(round your response to two decimal places).*

Lower Control Limit ($LCL_{\bar{x}}$) = 13.96 ounces *(round your response to two decimal places).*

$$UCL = \mu + A\sigma = \mu + \frac{3}{\sqrt{n}}\sigma$$

$$LCL = \mu - A\sigma = \mu - \frac{3}{\sqrt{n}}\sigma$$

contains	14	
standard deviation	0.10	
sample size	64	
Upper Control Limit	**14.04**	14+(3/SQRT(64)*0.1)= **14.04**
Lower Control Limit	**13.96**	14-(3/SQRT(64)*0.1)= **13.96**

Problem 6s.1

Question Help

Boxes of Honey-Nut Oatmeal are produced to contain 15.0 ounces, with a standard deviation of 0.20 ounce. For a sample size of 49, the *3-sigma* $\bar{x}$ chart control limits are:

Upper Control Limit ($UCL_{\bar{x}}$) = 15.09 ounces *(round your response to two decimal places).*

Lower Control Limit ($LCL_{\bar{x}}$) = 14.91 ounces *(round your response to two decimal places).*

contains	15	
st. dev	0.20	
sample size	49	
upper control limit	**15.09**	15+(3/SQRT(49)*0.2)=**15.09**
lower control limit	**14.91**	15-(3/SQRT(49)*0.2)=**14.91**

Problem 6s.11ac

Question Help

Refer to Table S6.1 - Factors for Computing Control Chart Limits (3 sigma) for this problem.

Twelve samples, each containing five parts, were taken from a process that produces steel rods at Emmanual Kodzi's factory. The length of each rod in the samples was determined. The results were tabulated and sample means and ranges were computed. The results were:

Sample	Sample Mean (in.)	Range (in.)	Sample	Sample Mean (in.)	Range (in.)
1	14.402	0.044	**7**	14.403	0.021
2	14.404	0.051	**8**	14.407	0.058
3	14.389	0.042	**9**	14.397	0.039
4	14.408	0.037	**10**	14.401	0.038
5	14.399	0.048	**11**	14.401	0.054
6	14.399	0.053	**12**	14.404	0.061

For the given data, the $\bar{\bar{x}}$ = 14.4002 inches *(round your response to four decimal places).*

Based on the sampling done, the control limits for *3-sigma* $\bar{x}$ chart are:

Upper Control Limit ($UCL_{\bar{x}}$) = 14.4275 inches *(round your response to four decimal places).*

Lower Control Limit ($LCL_{\bar{x}}$) = 14.3749 inches *(round your response to four decimal places).*

Based on the $\bar{x}$-chart, is one or more samples beyond the control limits? No .

For the given data, the $\bar{R}$ = 0.04550 inches *(round your response to four decimal places).*

The control limits for the 3-*sigma* R-chart are:

Upper Control Limit (UCL_R) = 0.0962 inches *(round your response to four decimal places).*

Lower Control Limit (LCL_R) = 0 inches *(round your response to four decimal places).*

Based on the R-chart, is one or more samples beyond the control limits? No .

Sample	Sample Mean (in.)	Range (in.)	Sample	Sample Mean (in.)	Range (in.)
1	14.402	0.044	7	14.403	0.021
2	14.404	0.051	8	14.407	0.058
3	14.389	0.042	9	14.397	0.039
4	14.408	0.037	10	14.401	0.038
5	14.399	0.048	11	14.401	0.054
6	14.399	0.053	12	14.404	0.061
x-bar	**14.4012**			r-bar	**0.04550**
x-bar					
upper control limit	**14.4275**	14.4012+(0.577*0.0455)=**14.4275**			
lower control limit	**14.3749**	14.4012-(0.577*0.0455)=**14.3749**			
R-bar					
upper control limit	**0.0962**	2.115*0.0455=**0.0962**			
lower control limit	**0**	0*0.0455=**0**			

Sample Size, n	Mean Factor, A_2	Upper Range, D_4	Lower Range, D_3
5	0.577	2.115	0

Problem 6s.15

Question

The results of inspection of DNA samples taken over the past 10 days are given below. Sample size is 100.

Day	1	2	3	4	5	6	7	8	9	10
Defectives	7	9	9	11	7	8	0	11	13	2

a) The upper and lower 3-*sigma* control chart limits are:

UCL_p = 0.157 *(enter your response as a number between 0 and 1, rounded to three decimal places).*

LCL_p = 0 *(enter your response as a number between 0 and 1, rounded to three decimal places).*

b) Given the limits in part a, is the process in control for the following days as shown in the table below?

Day	**Number of Defects**	**In-Control**
11	14	YES
12	8	YES
13	12	YES

Day	Defectives	sample size	fraction defective
1	7	100	0.07
2	9	100	0.09
3	9	100	0.09
4	11	100	0.11
5	7	100	0.07
6	8	100	0.08
7	0	100	0
8	11	100	0.11
9	13	100	0.13
10	2	100	0.02
average	**0.077**		
upper control limit	**0.157**	0.077+3*SQRT(((0.077)*(1-0.077))/100)=**0.157**	
lower control limit	**-0.003**	.077-3*SQRT(((0.077)*(1-0.077))/100)=**-0.003**	
	will be **0**, can't be negative		

Problem 6s.16

The defect rate for your product has historically been about 1.00%. For a sample size of 200, the upper and lower 3-*sigma* control chart limits are:

UCL_p = 0.0311 *(enter your response as a number between 0 and 1, rounded to four decimal places).*

LCL_p = 0.0000 *(enter your response as a number between 0 and 1, rounded to four decimal places).*

defect rate	1.00%	
sample size	200	
	0.0211	
Upper Control Limit	**0.03111**	0.01+(3*(SQRT(0.01*(1-0.01)/200)))=0.0311
Lower Control Limit	**-0.0111**	0.01-(3*(SQRT(0.01*(1-0.01)/200)))= -0.0111==>0.000 can't be negative
p=defect rate		
n=sample size		
z=3 (for 3-sigma chart)		

$$UCL = p + z\sqrt{\frac{p(1-p)}{n}}$$

Problem 6s.16

Question Help

The defect rate for your product has historically been about 2.00%. For a sample size of 500, the upper and lower 3-*sigma* control chart limits are:

UCL_p = 0.0388 *(enter your response as a number between 0 and 1, rounded to four decimal places).*

LCL_p = 0.0012 *(enter your response as a number between 0 and 1, rounded to four decimal places).*

defect rate, p	0.02	
sample size, n	500	
3-sigma, z		
upper control limit	**0.0388**	0.02+3*SQRT(((0.02)*(1-0.02))/500)=**0.0388**
lower control limit	**0.0012**	0.02-3*SQRT(((0.02)*(1-0.02))/500)=**0.0012**

Problem 6s.17

The defect rate for your product has historically been about 4.00%. For a sample size of 500, the upper and lower 3-*sigma* control chart limits are:

UCL_p = 0.0663 *(enter your response as a number between 0 and 1, rounded to four decimal places).*

LCL_p = 0.0137 *(enter your response as a number between 0 and 1, rounded to four decimal places).*

defect rate	4.00%	
sample size	500	
Upper Control Limit	**0.0663**	0.04+(3*(SQRT(0.04*(1-0.04)/500)))=**0.0663**
Lower Control Limit	**0.0137**	0.04-(3*(SQRT(0.04*(1-0.04)/500)))=**0.0137**
p=defect rate		
n=sample size		
z=3 (for 3-sigma chart)		

$$UCL = p + z\sqrt{\frac{p(1-p)}{n}}$$

Problem 6s.18

Question Help

Five data entry operators work at the data processing department of the Birmingham Bank. Each day for 30 days, the number of defective records in a sample of 250 records typed by these operators has been noted, as follows:

Sample No.	No. Defectives	Sample No.	No. Defectives	Sample No.	No. Defectives
1	7	11	7	21	18
2	4	12	6	22	13
3	20	13	17	23	7
4	10	14	5	24	8
5	12	15	11	25	14
6	9	16	8	26	9
7	12	17	13	27	13
8	10	18	4	28	5
9	5	19	17	29	12
10	13	20	16	30	2

a) Establish 3σ upper and lower control limits.

UCL_p = 0.078 *(enter your response as a number between 0 and 1, rounded to three decimal places).*

LCL_p = 0.003 *(enter your response as a number between 0 and 1, rounded to three decimal places).*

b) Why can the lower control limit not be a negative number?

- A. Since the percent of defective records is always a positive number.
- B. Since the upper control limit cannot be a negative number.
- ✔ C. Since the percent of defective records cannot be a negative number.
- D. Since the upper control limit is positive.

c) The industry standard for the upper control limit is 0.10. What does this imply about Birmingham Bank's own standards?

The industry standard is not as strict as the standard at Birmingham Bank.

Sample	# Defectives (np)	sample size n	fraction of defective(p=np/n)
1	7	250	0.028
2	4	250	0.016
3	20	250	0.08
4	10	250	0.04
5	12	250	0.048
6	9	250	0.036
7	12	250	0.048
8	10	250	0.04
9	5	250	0.02
10	13	250	0.052
11	7	250	0.028
12	6	250	0.024
13	17	250	0.068
14	5	250	0.02
15	11	250	0.044
16	8	250	0.032
17	13	250	0.052
18	4	250	0.016
19	17	250	0.068
20	16	250	0.064
21	18	250	0.072
22	13	250	0.052
23	7	250	0.028
24	8	250	0.032
25	14	250	0.056
26	9	250	0.036
27	13	250	0.052
28	5	250	0.02
29	12	250	0.048
30	2	250	0.008
TOTAL	**307**	**7500**	**1.228**
average	10.2333	250.0000	**0.0409**
upper control	**0.078**	0.0409+3*SQRT(((0.0409)*(1-0.0409))/250)=**0.078**	
lower control	**0.003**	0.0409-3*SQRT(((0.0409)*(1-0.0409))/250)=**0.03**	

Problem 6s.24

Question Help

Telephone inquiries of 100 IRS "customers" are monitored daily at random. Incidents of incorrect information or other nonconformities (such as impoliteness to customers) are recorded. The data for last week follow:

Day	No. of Nonconformities
1	3
2	7
3	24
4	18
5	11

a) Using 3 standard deviations, the *c*-chart for the nonconformities is:

UCL_c = 23.25 nonconformities *(round your response to two decimal places)*.

LCL_c = 1.95 nonconformities *(round your response to two decimal places and if your answer is negative, enter this value as 0)*.

b) According to the *c*-chart, there IS SIGNIFICANT variation in the incidents of incorrect information given out by the IRS telephone operators.

1	3			
2	7			
3	24			
4	18			
5	11			
average	12.6			
UCL	**23.25**	12.6+3*SQRT(12.6)=**23.25**		
LCL	**1.95**	12.6-3*SQRT(12.6)=**1.95**		

Control limits (99.73%) $=\overline{c}\pm 3\sqrt{\overline{c}}$

Problem 6s.26

Question Help

Refer to Table S6.1 - Factors for Computing Control Chart Limits (3 sigma) for this problem.

West Battery Corp. has recently been receiving complaints from retailers that its 9-volt batteries are not lasting as long as other name brands. James West, head of the TQM program at West's Austin plant, believes there is no problem because his batteries have had an average life of 40 hours, about 10% longer than competitors' models. To raise the lifetime above this level would require a new level of technology not available to West. Nevertheless, he is concerned enough to set up hourly assembly line checks. Previously, after ensuring that the process was running properly, West took samples of 5 9-volt batteries for 25 test to establish the standards for control chart limits. Those 25 tests are shown in the following table:

	Sample Data								Sample Data						
Hour Sample Taken	**1**	**2**	**3**	**4**	**5**	**$\bar{x}$**	**R**	**Hour Sample Taken**	**1**	**2**	**3**	**4**	**5**	**$\bar{x}$**	**R**
1	41	40	39	40	40	40.0	2	14	41	49	30	42	36	39.6	19
2	36	36	61	37	25	39.0	36	15	48	31	41	48	48	43.2	17
3	41	35	33	35	36	36.0	8	16	53	38	33	22	45	38.2	31
4	45	60	40	20	41	41.2	40	17	29	28	38	49	37	36.2	21
5	39	29	43	42	36	37.8	14	18	54	41	31	47	39	42.4	23
6	50	51	42	45	45	46.6	9	19	48	44	42	37	41	42.4	11
7	27	22	40	39	47	35.0	25	20	50	40	30	30	41	38.2	20
8	40	56	44	32	29	40.2	27	21	41	36	39	49	29	38.8	20
9	34	42	35	37	33	36.2	9	22	44	29	47	38	35	38.6	18
10	61	34	41	38	30	40.8	31	23	36	37	41	40	37	38.2	5
11	47	45	51	35	25	40.6	26	24	40	39	38	42	41	40.0	4
12	46	44	38	33	52	42.6	19	25	42	39	40	40	51	42.4	12
13	30	59	49	35	35	41.6	29								

This exercise contains only parts a and b.

a) For the given data, the $\bar{\bar{x}}$ = 39.832 hours *(round your response to three decimal places).*

For the given data, mean range = 19.040 hours *(round your response to two decimal places).*

With *z=3*, the control limits for the mean chart are:

$UCL_{\bar{x}}$ = 50.818 hours *(round your response to three decimal places).*

$LCL_{\bar{x}}$ = 28.846 hours *(round your response to three decimal places).*

The control limits for the range chart are:

UCL_R = 40.27 hours *(round your response to two decimal places).*

LCL_R = 0.00 hours *(round your response to two decimal places).*

$$UCL_{\bar{x}} = \bar{\bar{x}} + A_2\bar{R} \qquad UCL_R = D_4\bar{R}$$

$$LCL_{\bar{x}} = \bar{\bar{x}} - A_2\bar{R} \qquad LCL_R = D_3\bar{R}$$

average	**39.832**		**19.040**
x bar	**50.818**	39.832+0.577*19.04=**50.818**	
x bar	**28.846**	39.832-0.577*19.04=**28.846**	
r bar	**40.27**	19.04*2.115=**40.27**	
r bar	**0.00**	19.04*0=**0.00**	

With these limits established, West now takes 5 more hours of data, which are shown in the following table. Calculate the mean and range for each hour that the sample data is taken. *(Enter your responses for the mean to one decimal place and enter your responses for the range as whole numbers.)*

Hour Sample Taken	Sample Data 1	2	3	4	5	$\bar{x}$	R
26	38	41	30	48	50	41.4	20
27	34	42	39	36	57	41.6	23
28	54	39	39	35	44	42.2	19
29	48	60	35	41	50	46.8	25
30	35	27	37	43	43	37.0	16

b) Do the samples for hours 26 through 30 indicate that the process is in control?

Based on the $\bar{x}$-chart, the process has been IN CONTROL .

Based on the R-chart, the process has been IN CONTROL .

Problem 6s.27

Question Help

One of New England Air's top competitive priorities is on-time arrivals. Quality VP Clair Bond decided to personally monitor New England Air's performance. Each week for the past 30 weeks, Bond checked a random sample of 100 flight arrivals for on-time performance.

Click the icon to view the table that contains the number of flights that did not meet New England Air's definition of on time.

a) The overall fraction of late flights is 0.04 *(enter your response as a real number rounded to two decimal places.)*

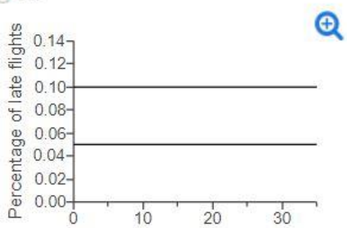
Using a 95% confidence level, the upper and lower control limits are:

Upper control limit (UCL_p) = 0.0784 *(enter your response as a fraction between 0 and 1, rounded to four decimal places).*

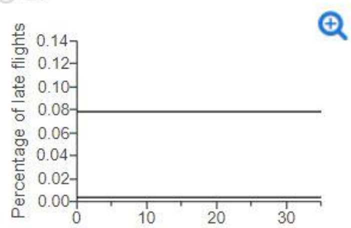
Lower control limit (LCL_p) = 0.0000 *(enter your response as a fraction between 0 and 1, rounded to four decimal places).*

b) Assume that the airline industry's upper and lower control limits for flights that are not on time are 0.1000 and 0.0500, respectively. Choose the correct control chart below.

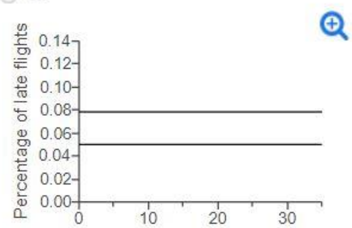
A.



B.



C.



$$UCL_p = \bar{p} + z\sigma_p$$

$$LCL_p = \bar{p} - z\sigma_p$$

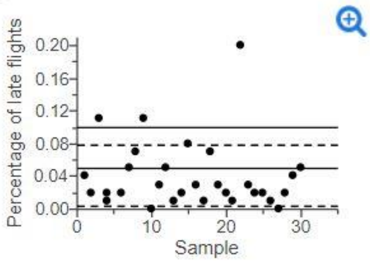
σ_p is estimated by

$$\hat{\sigma}_p = \sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$$

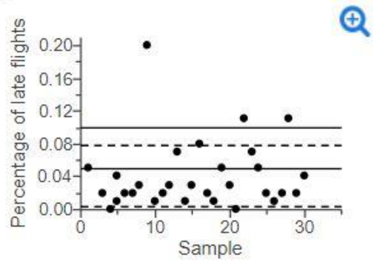
????

c) Choose the chart below that correctly plots the percentage of late flights in each sample.

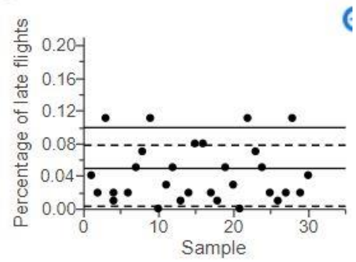
A.



B.



C.



Do all samples fall within New England Air's control limits?

- No
- Yes

When one falls outside the control limits, what should be done?

- A. Find new control limits so that each sample falls within new limits.
- B. An investigation, leading to corrective action, should be done.
- C. Nothing should be done.

d) What can Clair Bond report about the quality of service?

- A. Clair needs to report that the airline meets its own standards, but does not meet the industry standards.
- B. Clair needs to report that the airline meets the industry standards, but does not meet its own standards.
- C. Clair needs to report that the airline meets neither its own standards nor the industry standards.
- D. Clair needs to report that the airline meets both its own standards and the industry standards.

Problem 6s.29 (additional/static)

Question Help

Refer to the table Factors for Computing Control Chart Limits (3 sigma) for this problem.

The overall average of a process you are attempting to monitor is 50 units. The average range is 4 units. The sample size you are using is n = 5.

a) What are the upper and lower control limits of a 3 sigma mean chart?

Upper Control Limit ($UCL_{\bar{x}}$) = 52.308 units *(round your response to three decimal places).*

Lower Control Limit ($LCL_{\bar{x}}$) = 47.692 units *(round your response to three decimal places).*

b) What are the upper and lower control limits of the 3 sigma range chart?

Upper Control Limit (UCL_R) = 8.46 units *(round your response to two decimal places).*

Lower Control Limit (LCL_R) = 0.00 units *(round your response to two decimal places).*

$$UCL_{\bar{x}} = \bar{\bar{x}} + A_2\bar{R}$$
$$LCL_{\bar{x}} = \bar{\bar{x}} - A_2\bar{R}$$
$$UCL_R = D_4\bar{R}$$
$$LCL_R = D_3\bar{R}$$

x bar	**52.308**	50+4*0.577=**52.308**
x bar	**47.692**	50-4*0.577=**47.692**
r bar	**8.46**	4*2.115=**8.46**
r bar	**0**	4*0=**0.00**

Problem 6s.3

Refer to Table S6.1 - Factors for Computing Control Chart Limits (3 sigma) for this problem.

Thirty-five samples of size 7 each were taken from a fertilizer-bag-filling machine. The results were: Overall mean = 60.75 lb.; Average range $\bar{R}$ = 1.78 lb.

a) For the given sample size, the control limits for *3-sigma* $\bar{x}$ chart are:

Upper Control Limit ($UCL_{\bar{x}}$) = 61.496 lb. *(round your response to three decimal places).*

Lower Control Limit ($LCL_{\bar{x}}$) = 60.004 lb. *(round your response to three decimal places).*

b) The control limits for the 3-sigma R-chart are:

Upper Control Limit (UCL_R) = 3.425 lb. *(round your response to three decimal places).*

Lower Control Limit (LCL_R) = 0.135 lb. *(round your response to three decimal places).*

$$UCL_{\bar{x}} = \bar{\bar{x}} + A_2\bar{R}$$
$$LCL_{\bar{x}} = \bar{\bar{x}} - A_2\bar{R}$$
$$UCL_R = D_4\bar{R}$$
$$LCL_R = D_3\bar{R}$$

x bar	61.496	60.75+0.419*1.78=**61.496**
x bar	60.004	60.75-0.419*1.78=**60.004**
r bar	3.425	1.924*1.78=**3.425**
r bar	0.135	0.076*1.78=**0.135**

Problem 6s.31 (additional/static)

Question Help

Refer to the table Factors for Computing Control Chart Limits (3 sigma) for this problem.

Pet Products, Inc., caters to the growing market for cat supplies, with a full line of products ranging from litter to toys to flea powder. One of its newer products, a tube of fluid that prevents hairballs in long-haired cats, is produced by an automated machine set to fill each tube with 63.5 grams of paste.

To keep this filling process under control, four tubes are pulled randomly from the assembly line every 4 hours. After several days, the data shown in the table that follows resulted.

Sample	$\bar{x}$	R	Sample	$\bar{x}$	R	Sample	$\bar{x}$	R
1	63.5	2.0	10	63.5	1.3	19	63.8	1.3
2	63.6	1.0	11	63.3	1.8	20	63.5	1.6
3	63.7	1.7	12	63.2	1.0	21	63.9	1.0
4	63.9	0.9	13	63.6	1.8	22	63.2	1.8
5	63.4	1.2	14	63.3	1.5	23	63.3	1.7
6	63.0	1.6	15	63.4	1.7	24	64.0	2.0
7	63.2	1.8	16	63.4	1.4	25	63.4	1.5
8	63.3	1.3	17	63.5	1.1			
9	63.7	1.6	18	63.6	1.8			

Set control limits for this process for the $\bar{x}$-chart.

$UCL_{\bar{x}}$ = 64.58 grams *(round your response to two decimal places).*

$LCL_{\bar{x}}$ = 62.40 grams *(round your response to two decimal places).*

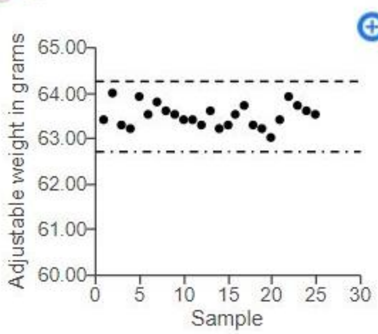
$$UCL_{\bar{x}} = \bar{\bar{X}} + A\bar{R}$$
$$LCL_{\bar{x}} = \bar{\bar{X}} - A\bar{R}$$

$$UCL_R = D_4\bar{R}$$
$$LCL_R = D_3\bar{R}$$

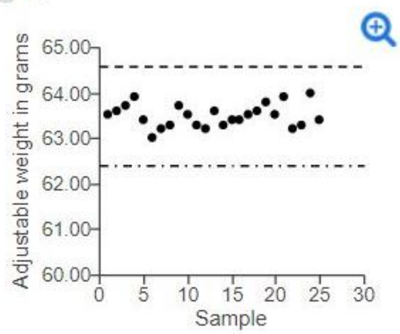
average	**63.488**	**1.496**
x bar	**64.579**	63.488+0.729*1.496=**64.579**
x bar	**62.397**	63.488-0.729*1.496=**62.397**
r bar	**3.414**	2.282*1.496=**3.414**
r bar	**0.000**	0*1.496=**0.00**

Choose the correct graph of the sample data for the $\bar{x}$-chart.

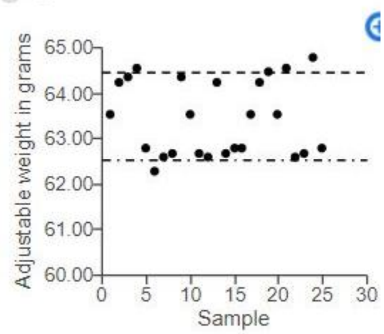
A.



B.



C.



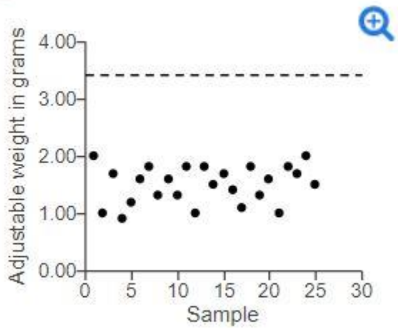
Set control limits for this process for the R-chart.

UCL_R = 3.41 grams *(round your response to two decimal places).*

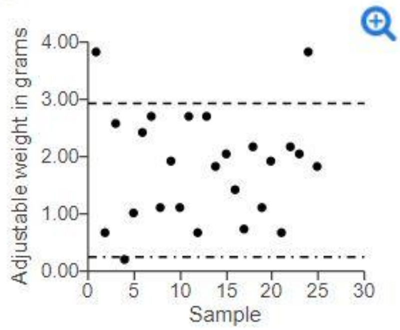
LCL_R = 0.00 grams *(round your response to two decimal places).*

Choose the correct graph of the sample data for the R-chart.

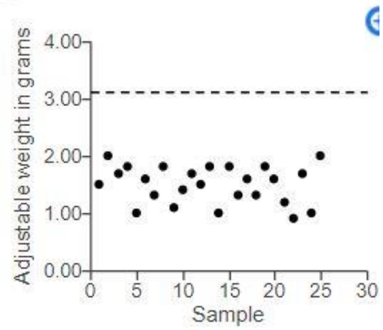
A.



B.



C.



Has the process been in control?

- Yes
- No

Problem 6s.33 (additional/static)

Question Help

Refer to the table Factors for Computing Control Chart Limits (3 sigma) for this problem.

Your supervisor, Lisa Lehmann, has asked that you report on the output of a machine on the factory floor. This machine is supposed to be producing optical lenses with a mean weight of 50 grams and a range of 3.5 grams. The following table contains the data for a sample size of n = 6 taken during the past 3 hours:

Sample	1	2	3	4	5	6	7	8	9	10
$\bar{x}$	55	47	49	50	52	57	55	48	51	56
R	3	1	5	3	2	6	3	2	2	3

Set the control limits for this process for the $\bar{x}$-chart when the machine is working properly.

$UCL_{\bar{x}}$ = 51.69 grams *(round your response to two decimal places).*

$LCL_{\bar{x}}$ = 48.31 grams *(round your response to two decimal places).*

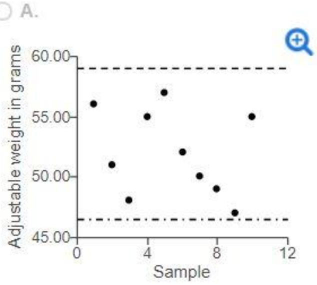
$$UCL_{\bar{x}} = \bar{\bar{X}} + A\bar{R}$$
$$LCL_{\bar{x}} = \bar{\bar{X}} - A\bar{R}$$

$$UCL_R = D_4\bar{R}$$
$$LCL_R = D_3\bar{R}$$

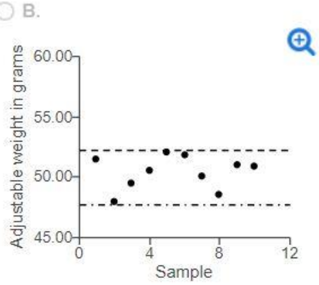
x bar	51.69	50+0.483*3.5=**51.69**
x bar	48.31	50-0.483*3.5=**48.31**
r bar	7.01	3.5*2.004=**7.01**
r bar	0.00	3.5*0=**0.00**

Choose the correct graph of the sample data for the $\bar{x}$-chart.

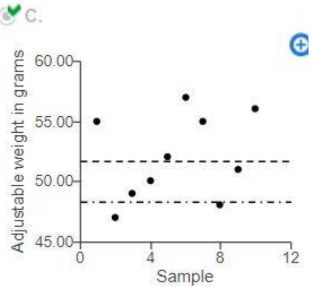
A.



B.



C.



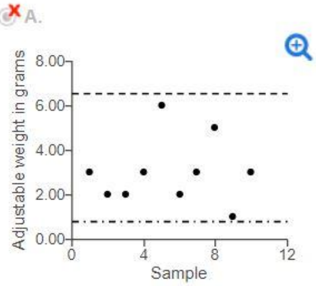
Set control limits for this process for the R-chart.

UCL_R = 7.01 grams *(round your response to two decimal places).*

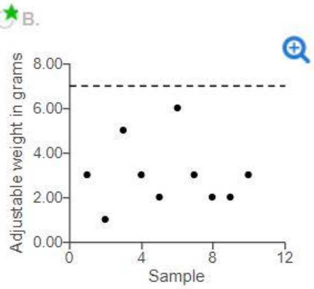
LCL_R = 0.00 grams *(round your response to two decimal places).*

Choose the correct graph of the sample data for the R-chart.

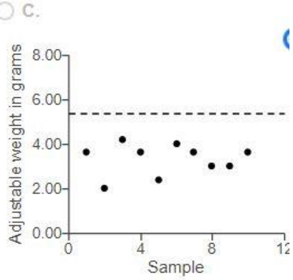
A.



B.



C.



Has the process been in control?

- No
- Yes

Problem 6s.36 (additional/static)

Question Help

The smallest defect in a computer chip will render the entire chip worthless. Therefore, tight quality control measures must be established to monitor these chips. In the past, the percentage defective at a California-based company has been 1.1%. The sample size is 1,000. Determine upper and lower control chart limits for these computer chips. Use z = 3.

Upper Control Limit (UCL_p) = 0.0209 *(round your response to four decimal places).*

Lower Control Limit (LCL_p) = 0.0011 *(round your response to four decimal places).*

Problem 6s.37 (additional/static)

Question Help

Daily samples of 100 power drills are removed from Drill Master's assembly line and inspected for defects. Over the past 21 days, the following information has been gathered:

Day	Number of Defective Drills	Day	Number of Defective Drills	Day	Number of Defective Drills
1	6	8	3	15	4
2	5	9	6	16	5
3	6	10	3	17	6
4	4	11	7	18	5
5	3	12	5	19	4
6	4	13	4	20	3
7	5	14	3	21	7

Set the control limits for a 3 standard deviation (99.73% confidence) p-chart.

Upper Control Limit (UCL_p) = 0.1100 *(round your response to four decimal p*

Lower Control Limit (LCL_p) = 0.0000 *(round your response to four decimal pl*

$$UCL_p = \bar{p} + z\sigma_p$$

$$LCL_p = \bar{p} - z\sigma_p$$

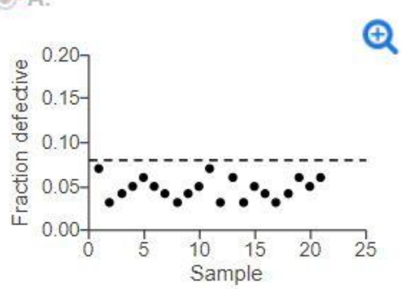
σ_p is estimated by

$$\hat{\sigma}_p = \sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$$

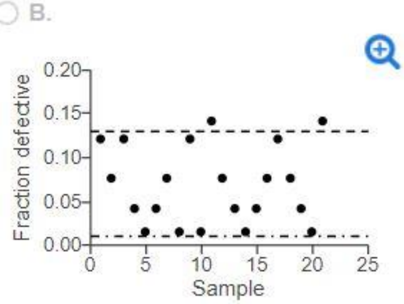
average	**0.0467**	
UCL	**0.1100**	0.0467+3*SQRT(((0.0467)*(1-0.0467))/(100))=**0.1100**
LCL	**-0.0166**	0.0467-3*SQRT(((0.0467)*(1-0.0467))/(100))=**0.00**

Choose the correct graph of the sample data for the p-chart.

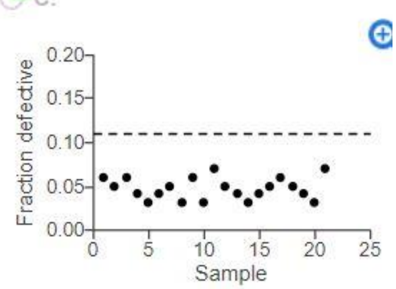
A.



B.



C.



Has the process been in control?

- Yes
- No

Problem 6s.40

The difference between the upper specification and the lower specification for a process is 0.50. The standard deviation is 0.10. Based on the given information, the process capability ratio, C_p = 0.83 *(round your response to two decimal places).*

Based on the process capability ratio (C_p) for the given information, one can say that the process is not at all capable to produce within the design specifications.

Process capability (Cp)= (USL-LSL)/(6* Std Dev)

$$C_{pk} = \text{min. of}\left[\frac{USL - \bar{\bar{x}}}{3\sigma}, \frac{\bar{\bar{x}} - LSL}{3\sigma}\right]$$

where $\bar{\bar{x}}$ = process mean
σ = standard deviation of the process population

Problem 6s.42

Linda Boardman, Inc., an equipment manufacturer in Boston, has submitted a sample cutoff valve to improve your manufacturing process. Your process engineering department has conducted experiments and found that the valve has a mean (μ) of 9.00 and a standard deviation (σ) of 0.06. Your desired performance is μ = 9.00 ± 3 standard deviations, where σ = 0.055.

For the given information, the process capability index (C_{pk}) = 0.917 *(round your response to three decimal places).*

mean	9	
standard deviation	0.06	
desired performance is 9.00 ± 3 standard deviations, where st. dev=0.055		
upper control limit	9.165	
lower control limit	8.835	
process capacity index	**0.917**	((9.165-9)/(3*0.06))=**0.917**
	0.917	((9-8.835)/(3*0.06))=**0.917**

$$C_{pk} = \text{min. of}\left[\frac{USL - \bar{\bar{x}}}{3\sigma}, \frac{\bar{\bar{x}} - LSL}{3\sigma}\right]$$

where $\bar{\bar{x}}$ = process mean
σ = standard deviation of the process population

Problem 6s.43

Question Help

The specifications for a plastic liner for a concrete highway project calls for thickness of 4.0 mm ± 0.12 mm. The standard deviation of the process is estimated to be 0.02 mm.

The upper specification limit for this product = 4.120 mm *(round your response to three decimal places).*

The lower specification limit for this product = 3.880 mm *(round your response to three decimal places).*

The process is known to operate at a mean thickness of 4.0 mm. The process capability index (C_{pk}) = 2.000 *(round your response to three decimal places).*

The upper specification limit lies about 6 standard deviations from the centerline (mean thickness).

st dev	0.02				
	4.0±0.12				
upper	**4.120**	4+0.12=**4.120**			
lower	**3.880**	4-0.12=**3.880**			
mean thicknes	4.0				
process capability index		**2.000**	(4.12-4)/(3*0.02)=**2.000**		
upper specification limit		**2.000**	(4-3.88)/(3*0.02)=**2.000**		
		(USL- Centerline)/st. dev			
upper specification	**6**	(4.12-4)/0.02=**6**			

Problem 6s.44

Question Help

Frank Pianki, the manager of an organic yogurt processing plant desires a quality specification with a mean of 18.0 ounces, an upper specification limit of 18.9 ounces, and a lower specification limit of 17.1 ounces. The process has a mean of 18.0 ounces and a standard deviation of 1.25 ounce.

The process capability index (C_{pk}) = 0.240 *(round your response to three decimal places).*

$$C_{pk} = \text{min. of}\left[\frac{USL - \bar{\bar{X}}}{3\sigma}, \frac{\bar{\bar{X}} - LSL}{3\sigma}\right]$$

0.240	(18.9-18)/(3*1.25)=**0.240**

Problem 6s.51

As the supervisor in charge of shipping and receiving, you need to determine *the average outgoing quality* in a plant where the known incoming lots from your assembly line have an average defective rate of 5.0%. Your plan is to sample 80 units of every 1,000 in a lot. The number of defects in a sample is not to exceed 3. Such a plan provides you with a probability of acceptance of each lot of 0.79 (79%).

The average outgoing quality for the plant is = 3.63 % *(enter your response as a percentage rounded to two decimal places).*

$$AOQ = \frac{P_d \times P_D \times (N-n)}{N}$$

P_d = True percentage defective of the lot=0.05

P_D = Probability of accepting the lot for a sample=0.79

N = Number of items in the lot=1000

n = number of items in the sample=80

$$AOQ = \frac{P_d \times P_D \times (N-n)}{N}$$

$$= \frac{0.05 * 0.79 * (1000-80)}{1000}$$

$$= 0.03634$$

$$= 3.634\%$$

Problem 6s.52

An acceptance sampling plan has lots of 500 pieces and a sample size of 60. The number of defects in the sample may not exceed 2. This plan, based on an OC curve, has a probability of 0.57 (57%) of accepting lots when the incoming lots have a defective rate of 5.0%, which is the historical average of the process.

For the customers, the average outgoing quality = 2.51 % *(enter your response as a percentage rounded to two decimal places).*

lot size	500	
sample size	60	
defect criteria=not to exceed 2		
Pd=true percent defective of lot	0.05	
Pa=probabilty of accepting the lot	0.57	
N=number of items in the lot	500	
n=number of items in the sample	60	
	0.0251	(0.05*0.57*(500-60))/500=**0.0251**
	2.51%	

$$AOQ = \frac{P_d \times P_D \times (N-n)}{N}$$

Problem 6s.7

Question Help

Refer to Table S6.1 - Factors for Computing Control Chart Limits (3 sigma) for this problem.

Auto pistons at Wemming Chung's plant in Shanghai are produced in a forging process, and the diameter is a critical factor that must be controlled. From sample sizes of 10 pistons produced each day, the mean and the range of this diameter have been as follows:

Day	Mean $\bar{x}$ (mm)	Range R (mm)
1	158.9	4.4
2	155.2	4.4
3	153.6	3.9
4	155.5	5.0
5	156.6	4.3

a) What is the value of $\bar{\bar{x}}$?

$\bar{\bar{x}}$ = 155.96 mm *(round your response to two decimal places).*

b) What is the value of $\bar{R}$?

$\bar{R}$ = 4.40 mm *(round your response to two decimal places).*

c) What are the $UCL_{\bar{x}}$ and $LCL_{\bar{x}}$ using *3-sigma*?

Upper Control Limit ($UCL_{\bar{x}}$) = 157.32 mm *(round your response to two decimal places).*

Lower Control Limit ($LCL_{\bar{x}}$) = 154.60 mm *(round your response to two decimal places).*

d) What are the UCL_R and LCL_R using *3-sigma*?

Upper Control Limit (UCL_R) = 7.82 mm *(round your response to two decimal places).*

Lower Control Limit (LCL_R) = 0.98 mm *(round your response to two decimal places).*

e) If the true diameter mean should be 155 mm and you want this as your center (nominal) line, what are the new $UCL_{\bar{x}}$ and $LCL_{\bar{x}}$?

Upper Control Limit ($UCL_{\bar{x}}$) = 156.36 mm *(round your response to two decimal places).*

Lower Control Limit ($LCL_{\bar{x}}$) = 153.64 mm *(round your response to two decimal places).*

Day	Mean	Range
1	158.9	4.4
2	155.2	4.4
3	153.6	3.9
4	155.5	5
5	156.6	4.3

Sample Size, n	Mean Factor, A_2	Upper Range, D_4	Lower Range, D_3
10	0.308	1.777	0.223

mean	**155.96**	
sample size	10	
number of samples	5	
average range	**4.40**	
x-bar		
upper control limit	**157.32**	155.96+(0.308*4.4)=**157.32**
lower control limit	**154.60**	155.96-(0.308*4.4)=**154.60**
r-bar		
upper control limit	**7.82**	1.777*4.4=**7.82**
lower control limit	**0.98**	0.223*4.4=**0.98**
x-bar		
upper control limit	**156.36**	155+(0.308*4.4)=**156.36**
lower control limit	**153.64**	155-(0.308*4.4)=**152.64**

$$UCL_{\bar{x}} = \bar{\bar{X}} + A\bar{R}$$

$$LCL_{\bar{x}} = \bar{\bar{X}} - A\bar{R}$$

$$UCL_R = D_4\bar{R}$$

$$LCL_R = D_3\bar{R}$$

Problem 6s.9

Question Help

Organic Grains LLC uses statistical process control to ensure that its health-conscious, low-fat, multigrain sandwich loaves have the proper weight.

Based on a previously stable and in-control process, the control limits of the $\bar{x}$- and R-charts are:

$UCL_{\bar{x}} = 7.14$, $LCL_{\bar{x}} = 6.66$;
$UCL_R = 1.074$, $LCL_R = 0$.

Over the past few days, they have taken five random samples of four loaves each and have found the following:

	Net Weight			
Sample	Loaf # 1	Loaf # 2	Loaf # 3	Loaf # 4
1	7.1	7.2	7.4	7.1
2	7.0	6.8	6.9	6.9
3	6.3	6.5	6.1	6.4
4	6.6	7.0	6.8	6.9
5	6.4	6.6	6.5	6.8

Based on the $\bar{x}$-chart, is one or more samples beyond the control limits? Yes .

Based on the R-chart, is one or more samples beyond the control limits? No .

	Net Weight							
Sample	Loaf # 1	Loaf # 2	Loaf # 3	Loaf # 4	sample mean	maximum weight	minimum weight	sample range
1	7.1	7.2	7.4	7.1	7.2	7.4	7.1	0.3
2	7	6.8	6.9	6.9	6.9	7	6.8	0.2
3	6.3	6.5	6.1	6.4	6.325	6.5	6.1	0.4
4	6.6	7	6.8	6.9	6.825	7	6.6	0.4
5	6.4	6.6	6.5	6.8	6.575	6.8	6.4	0.4
Means				x-bar	**6.765**		r-bar	**0.34**

Problem 6s.22

Question Help

An ad agency tracks the complaints, by week received, about the billboards in its city:

Week	No. of Complaints
1	7
2	7
3	5
4	7
5	4
6	19

This exercise contains only parts a, b, and c.

a) The type of control chart that is best to monitor this process is c − chart .

b) Using z = 3, the control chart limits for this process are (assume that the historical complaints rate is unknown):

UCL_c = 16.74 complaints per week *(round your response to two decimal places).*

LCL_c = 0.00 complaints per week *(round your response to two decimal places and if your answer is negative, enter this value as 0).*

c) According to the control limits, the process has been OUT OF CONTROL .

$$\text{Upper control limit } (UCL) = \text{Average value of attributes} + z \times \sqrt{\text{Average value of attributes}}$$

$$\text{Lower control limit } (LCL) = \text{Average value of attributes} - z \times \sqrt{\text{Average value of attributes}}$$

Day	No. of Nonconformities		
1	7		
2	7		
3	5		
4	7		
5	4		
	19		
avg	8.17		
	16.74	E19+3*SQRT(E19)=**16.74**	