

Six Sigma Green Belt Certification

What Is the Objective of This Chapter?

The objective of this chapter is to prepare you for the Six Sigma Green Belt examination. Once you have passed the Green Belt examination, and completed a Six Sigma DMAIC project that has been approved by a Six Sigma Master Black belt, you will be a Six Sigma Green Belt.

Sample Green Belt Certification Examination Questions with Answers

Green Belt certification examinations assume that you have successfully completed the Champion certification examination. This section only presents questions beyond the Champion certification level. However, Green Belt certification examinations are cumulative in that they cover the material required for both Champion and Green Belt certification.

NOTE

A laptop computer with Minitab 17 and Microsoft Word is required to sit for the Green Belt certification examination. Minitab is one of the most popular statistical software packages for Six Sigma. You can rent or purchase Minitab from www.minitab.com. Minitab with control charts only exists for PCs.

Question: What is data?

Answer: Data is information collected about a product, service, process, individual, item, or thing. Because no two things are exactly alike, data inherently varies. Each characteristic of interest is referred to as a variable. Data can also be words, sounds, and pictures, to name a few types.

Question: What is attribute data?

Answer: Attribute data (also referred to as classification or count data) occurs when a variable is either classified into categories (defective or conforming) or used to count occurrences of a phenomenon (number of patient falls on a particular hospital floor in a particular month).

Question: Give some examples of attribute classification data.

Answer:

- Percent of accounts receivable older than 90 days per month. Either the account is over 90 days or it isn't over 90 days; there are only two categories.
- Percent of employees off sick by supervisor by day. Either the employee is off sick or not; there are only two categories.
- Percent of occurrences of surgery delays in an operating room by month. Either the surgery is delayed or not; again, there are only two categories.

Question: Give some examples of attribute count data.

Answer:

- The number of data entry errors on a patient chart by chart
- The number of cars entering a hospital parking garage by day
- The number of surgeries performed on the wrong patient per year

Question: What is measurement data?

Answer: Measurement data (also referred to as continuous or variables data) results from a measurement taken on an item of interest, or the computation of a numerical value from two or more measurements of variables data. Any value can theoretically occur, limited only by the precision of the measuring process. This type of data can have decimal points.

Question: Give some examples of measurement data.

Answer:

- Height by person
- Waiting time by patient
- Revenue by month
- Cost by line item by store by month

Question: What is a bar chart?

Answer: A bar chart presents each category of a count attribute variable as a bar whose length is the frequency or percentage of observations falling into a particular category. The width of the bar is meaningless for a bar chart, but all bars should be the same width.

Question: What is the purpose of a Pareto diagram?

Answer: Pareto diagrams are used to identify and prioritize issues that contribute to a problem we want to solve. Pareto analysis focuses on distinguishing the vital few causes of problems from the trivial many causes of problems. The vital few are the few causes that account for the largest percentage of the problem, while the trivial many are the myriad of causes that account for a small percentage of the problem.

Question: What is a line graph?

Answer: A line graph is a graph of any type of variable plotted on the vertical axis and usually time plotted on the horizontal axis.

Question: What is a histogram?

Answer: A histogram is a special bar chart for measurement data. In the histogram, the data is grouped into adjacent numerical categories of equal size, for example, 100 to less than 200, 200 to less than 300, 300 to less than 400, and so on. The difference between a bar chart and a histogram is that the X axis on a bar chart is a listing of categories, whereas the X axis on a histogram is a measurement scale. In addition there are no gaps between adjacent bars.

Question: What is a dot plot?

Answer: Similar to a histogram, a dot plot is a graph of measurement data in which dots that represent data values are stacked vertically on the horizontal axis for each value of the variable of interest.

Question: What is a run chart?

Answer: A run chart is a type of line chart that has multiple measurements for each time period, called subgroups. Time is the x-axis and the variable of interest is plotted on the y-axis; remember there will be multiple data points on the y-axis for each time period on the x-axis.

Question: What is the mean?

Answer: The most common numerical representation of central tendency is the arithmetic average or mean. It is the sum of the numerical values of the items being measured divided by the number of items. Because its computation is based on every observation, the arithmetic mean is greatly affected by any extreme value or values, so be careful because you may get a distorted representation of what the data are conveying!

Question: What is the median?

Answer: The median is the middle value in a set of data that has been ordered from the lowest to the highest value. Half the observations will be smaller than the median, and half will be larger. The median is not affected by any extreme values in a set of data.

Question: What is the proportion?

Answer: Often data are classified into two non-numerical conditions, such as broken versus not broken, defective versus conforming, operating versus not operating. The proportion or fraction of the data possessing one of two such conditions is a meaningful measure of central tendency.

Question: What is the range?

Answer: The range is simply the difference between the largest and the smallest data points in the data set. It is calculated by subtracting the smallest number from the largest number.

Question: Give an example of the range.

Answer: Given the following data: 34, 12, 23, 29, 31, 15, 21, 19, compute the range.

Range = largest value – smallest value

Range = 34 – 12 = 22

Question: What are the variance and standard deviation?

Answer: The variance and standard deviation measure how far the values in a data set are spread out around the average. A variance or standard deviation of zero indicates all the values in the data set are the same.

Question: Compute the variance and standard deviation from the following data:

39, 29, 43, 52, 39, 44, 40, 31, 44, and 35.

Answer: Let's use the example of our time to get ready in the morning to help us understand variance and standard deviation. The times to get ready are listed in Table 18.1.

Table 18.1 Time to Get Ready for Ten Days Used to Calculate Variance and Standard Deviation

Time (X)	Difference Between X and Mean	Squared Differences Around the Mean
39	-0.6	0.36
29	-10.6	112.36
43	3.4	11.56
52	12.4	153.76
39	-0.6	0.36
44	4.4	19.36
40	0.4	0.16
31	-8.6	73.96
44	4.4	19.36
35	-4.6	21.16
Mean = 39.6	Sum of differences = 0	Sum of squared differences = 412.4

To calculate the variance we take the following steps:

1. We subtract each value from the mean; see the middle column in Table 18.1.
2. We square those numbers and add them up to get the sum of squared differences, which is 412.4, as you see at the bottom of the right column in Table 18.1.
3. Finally, we divide the sum of squared differences by the number of observations (10 minus one, which gives us $412.4/9 = 45.82$).

To calculate the standard deviation we simply take the square root of the variance, which is 6.77.

Question: Explain the meaning of the range, variance, and standard deviation.

Answer: The following statements summarize what you need to know about the range, variance, and standard deviation:

- The more spread out, or dispersed, the data are, the larger will be the range, the variance, and the standard deviation.
- The more concentrated or homogeneous the data is, the smaller will be the range, the variance, and the standard deviation.
- If the values are all the same (so that there is no variation in the data), the range, the variance, and the standard deviation will all be zero.
- The range, variation, or standard deviation will always be greater than or equal to zero.
- The range can be a deceptive measure of dispersion if there are extreme values in the data set.

Question: What is skewness?

Answer: Skewness is a measure of the size of the right or left tail of a unimodal (one hump) distribution. There are three types of skewness: symmetrical, positive or right skewness, and negative or left skewness.

Question: If the distribution of output from a process is unimodal, symmetric, and bell shaped, we call this distribution the normal distribution. The normal distribution has some properties that are worth mentioning here to improve your understanding of the standard deviation. What percentage of the data in a normal distribution lay between the mean and plus or minus two standard deviations from the mean?

Answer: If you create a region under the normal distribution that is plus or minus two standard deviations from the mean, then 95.44% of the output from the process that generated the normal distribution will lie in that area.

Question: Construct and interpret the control chart for the following data. Consider the case of a large health system that has had several complaints from several pathologists concerning a supposed problem with a manufacturer sending cracked slides. Slides are pieces of glass that

pathologists place biopsies on so they can be examined under a microscope. This allows the pathologist to assist the clinician in confirming a diagnosis of the disease from the biopsy. According to the pathologists, some slides are cracked or broken before or during transit, rendering them useless scrap. The fraction of cracked or broken slides is naturally of concern to the hospital administration. Each day a sample of 100 slides is drawn from the total of all slides received from each slide vendor. Table 18.2 presents the sample results for 30 days of incoming shipments for a particular vendor.

Table 18.2 30 Days of Incoming Slide Shipments for a Particular Vendor

Day	Sample Size	Number Cracked
1	100	14
2	100	2
3	100	11
4	100	4
5	100	9
6	100	7
7	100	4
8	100	6
9	100	3
10	100	2
11	100	3
12	100	8
13	100	4
14	100	15
15	100	5

Day	Sample Size	Number Cracked
16	100	3
17	100	8
18	100	4
19	100	2
20	100	5
21	100	5
22	100	7
23	100	9
24	100	1
25	100	3
26	100	12
27	100	9
28	100	3
29	100	6
30	100	9

Answer: These data are appropriate for a p chart (see Figure 18.1) because each slide is classified as cracked (defective) or not cracked (nonconforming). The probability of a cracked slide is assumed to be constant from slide to slide, and each slide is considered independent of the other slides.

The process lacks control. On day 1, the proportion of cracked slides ($14/100 = 0.14$) is above the upper control limit, and on day 14 the proportion of cracked slides ($15/100 = 0.15$) is above the upper control limit.

Question: Construct and interpret a control chart for the following data. Consider the number of add-ons (unscheduled patients) in an outpatient clinic in a hospital. Many times patients are added on to the regular schedule at the last minute or the same day. This is problematic as the capacity of the clinic is limited and add-ons create problematic wait times,

usually too long for patient satisfaction to be at an acceptable level. A process improvement team collected data on the number of add-ons per day at one of its outpatient clinics. Results of these data collections produce the results in Table 18.3.

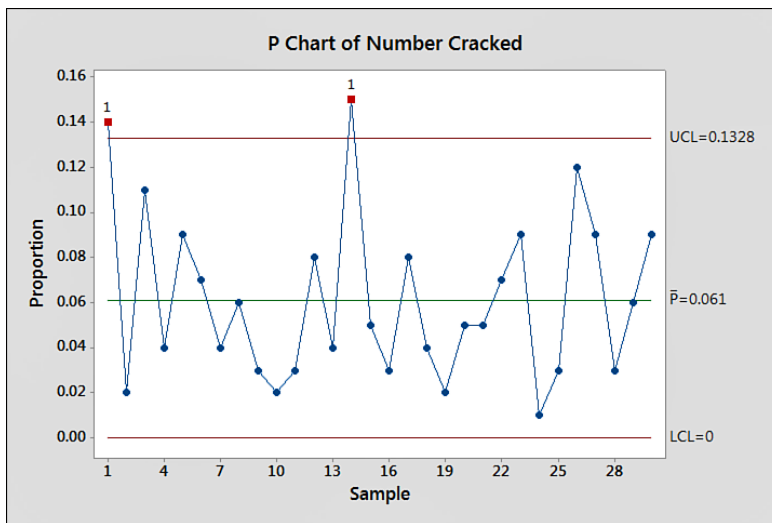


Figure 18.1 P chart of number of cracked tiles

Table 18.3 Number of Add-ons per Day for 50 Consecutive Days in an Outpatient Clinic

Day	Add-ons	Day	Add-ons	Day	Add-ons
1	13	14	12	27	16
2	19	15	16	28	15
3	9	16	12	29	18
4	21	17	14	30	19
5	18	18	14	31	10
6	13	19	14	32	14
7	18	20	13	33	14
8	19	21	14	34	12
9	19	22	11	35	16
10	15	23	17	36	12
11	11	24	11	37	8
12	9	25	15	38	12
13	16	26	21	39	20

Day	Add-ons
40	24
41	11
42	10
43	10

Day	Add-ons
44	5
45	17
46	14
47	11

Day	Add-ons
48	23
49	13
50	8

Answer: The assumptions necessary for using the c chart are well met here, as the clinic days are considered to be the areas of opportunity; add-ons are discrete events and seem to be independent of one another (see Figure 18.2). Even if these conditions are not precisely met, the c chart is fairly robust or insensitive to small departures from the assumptions.

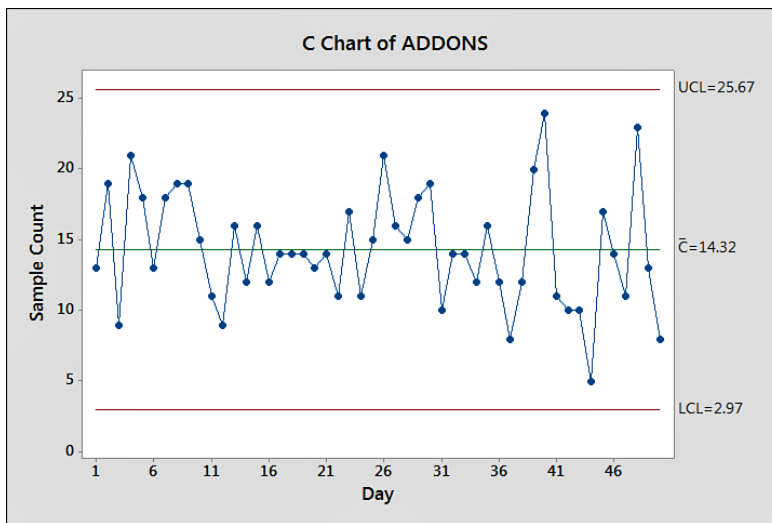


Figure 18.2 C chart of the number of add-ons per day for 50 consecutive days in an outpatient clinic

The number of add-ons appears to be stable around a center line or mean of 14.32.

Question: Construct and interpret a control chart from the following data. Consider a pathology department of a hospital who needs to provide diagnosis of GI biopsies in a timely manner. There are many steps in the process including extracting the biopsy from the patient, lab processing, reading, and sign-out by the faculty. The hospital administration is concerned with the turnaround times for GI biopsies taking too long. Turnaround times for 100 consecutive GI biopsy cases is shown Table 18.4.

Table 18.4 Turnaround Times for 100 Consecutive GI Biopsy Cases

GI Biopsy Turnaround Times in Days		GI Biopsy Turnaround Times in Days		GI Biopsy Turnaround Times in Days	
Case	Turnaround Times in Days	Case	Turnaround Times in Days	Case	Turnaround Times in Days
1	4.3	35	3.1	69	4.9
2	5.1	36	4.8	70	3.6
3	2.9	37	4.1	71	4
4	3.3	38	3.1	72	2.6
5	4.4	39	3.3	73	3.2
6	3.8	40	4.3	74	5.6
7	5.8	41	2.9	75	4.4
8	3.7	42	2.4	76	5.1
9	4.3	43	2.4	77	5.8
10	5.2	44	4.5	78	4.4
11	4.2	45	3.4	79	4.1
12	3.6	46	5	80	2.5
13	4	47	2.9	81	1.9
14	2.5	48	4.7	82	3.6
15	5.3	49	3.9	83	4.9
16	4.9	50	4.2	84	3.8
17	4.8	51	2.2	85	4.5
18	6.4	52	4.6	86	5.2
19	4.2	53	2.4	87	5
20	3.4	54	5.5	88	1.8
21	4	55	4.1	89	4.8
22	4.2	56	4.6	90	3.8
23	3.9	57	4.7	91	5.1
24	2.2	58	3.7	92	3.6
25	5.5	59	4.6	93	5.3
26	4.6	60	3.6	94	3.6
27	2.8	61	3.8	95	4.3
28	2.6	62	4.2	96	4.3
29	3.6	63	5.4	97	3.7
30	4	64	4.8	98	2.9
31	6	65	5.9	99	2
32	5.4	66	3.9	100	4.5
33	2.6	67	3.9		
34	4.5	68	4		

Answer:

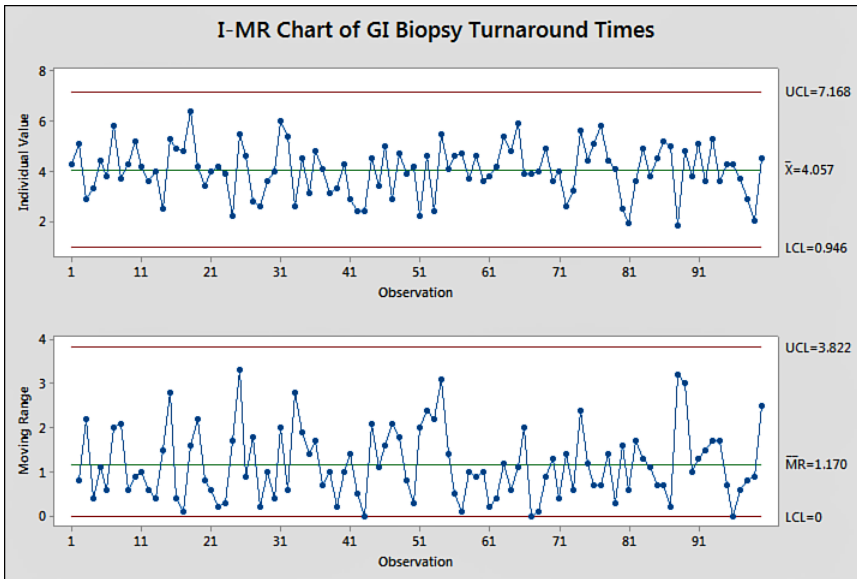


Figure 18.3 I-MR chart for the turnaround times for 100 consecutive GI biopsy cases

The bottom portion in Figure 18.3 is the moving range chart and the top portion is the individual value chart. First, the moving range chart is examined for signs of special variation. None of the points on the moving range chart is outside the control limits, and there are no other signals indicating a lack of control. Thus, there are no indications of special sources of variation on the moving range chart. Now the individual value chart can be examined. There are no indications of a lack of control, so the process can be considered to be stable and the output predictable with respect to time as long as conditions remain the same.

Question: Construct and interpret a control chart for the following data. Consider a large pharmaceutical firm that provides vials filled to a specification of 52.0 grams. The firm's management has embarked on a program of statistical process control and has decided to use variables control charts for this filling process to detect special causes of variation. Samples of six vials are selected every 5 minutes during a 105-minute period. Each set of six measurements makes up a subgroup. Table 18.5 lists the vial weights for 22 subgroups.

Table 18.5 Vial Weights for Six Vials Selected During 22 Time Periods

Observation	Time	1	2	3	4	5	6
1	9:30	52.22	52.85	52.41	52.55	53.10	52.47
2	9:35	52.25	52.14	51.79	52.18	52.26	51.94
3	9:40	52.37	52.69	52.26	52.53	52.34	52.81
4	9:45	52.46	52.32	52.34	52.08	52.07	52.07
5	9:50	52.06	52.35	51.85	52.02	52.30	52.20
6	9:55	52.59	51.79	52.20	51.90	51.88	52.83
7	10:00	51.82	52.12	52.47	51.82	52.49	52.60
8	10:05	52.51	52.80	52.00	52.47	51.91	51.74
9	10:10	52.13	52.26	52.00	51.89	52.11	52.27
10	10:15	51.18	52.31	51.24	51.59	51.46	51.47
11	10:20	51.74	52.23	52.23	51.70	52.12	52.12
12	10:25	52.38	52.20	52.06	52.08	52.10	52.01
13	10:30	51.68	52.06	51.90	51.78	51.85	51.40
14	10:35	51.84	52.15	52.18	52.07	52.22	51.78
15	10:40	51.98	52.31	51.71	51.97	52.11	52.10
16	10:45	52.32	52.43	53.00	52.26	52.15	52.36
17	10:50	51.92	52.67	52.80	52.89	52.56	52.23
18	10:55	51.94	51.96	52.73	52.72	51.94	52.99
19	11:00	51.39	51.59	52.44	51.94	51.39	51.67
20	11:05	51.55	51.77	52.41	52.32	51.22	52.04
21	11:10	51.97	51.52	51.48	52.35	51.45	52.19
22	11:15	52.15	51.67	51.67	52.16	52.07	51.81

Answer:

In Figure 18.4 the bottom portion is the R chart, and the top portion is the X Bar chart. First, the R chart is examined for signs of special variation. None of the points on the R chart is outside the control limits, and there are no other signals indicating a lack of control. Thus, there are no indications of special sources of variation on the R chart.

Now the X Bar chart can be examined. Notice that a total of five points on the X Bar chart are outside the control limits (1, 3, 10, 17, and 19), and points 16, 17, and 18 are above +2 standard deviations (2 out of 3 points 2 sigma or beyond rule). Also notice that 18 through 22 show the same type of pattern as points 16 through 18. This indicates a lack of control. An interesting point comes up here. If the high points are resolved, then the low points may be in control and vice versa. This type of analysis requires a process expert.

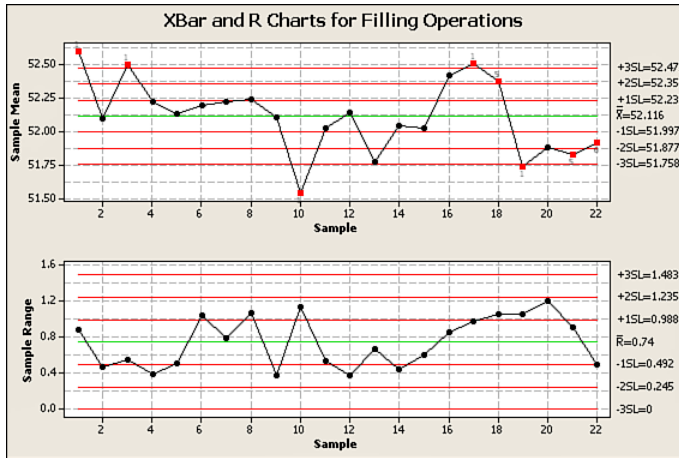


Figure 18.4 X-bar and R chart for the vial weights for six vials selected during 22 time periods

Further investigation is warranted to determine the source(s) of these special variations. The next step is to eliminate the bad special causes of variation and instill the good special causes of variation. Once this is done, the next step is to reduce the common causes of variation in the process.

Question: Construct and interpret a control chart for the following data. Consider a hospital is studying the length of time patients spend in the admitting process. Samples of 12 patients are selected each day for a 20 day period. The first patient to arrive on the hour is sampled, and the hospital clinic is open 12 hours per day. Admitting time has been operationally defined to all stakeholders' satisfaction. It is measured in seconds and is seen in Table 18.6.

Table 18.6 Admitting Process Time in Seconds

Day	Patient Time	Day	Patient Time	Day	Patient Time
1	362	1	884	2	521
1	468	1	904	2	959
1	553	2	611	2	315
1	390	2	873	2	414
1	460	2	768	3	320
1	910	2	807	3	944
1	707	2	476	3	593
1	829	2	816	3	857
1	955	2	567	3	710
1	705	2	833	3	724

Day	Patient Time
3	545
3	526
3	348
3	456
3	576
3	855
4	621
4	927
4	948
4	817
4	641
4	764
4	986
4	430
4	743
4	451
4	645
4	996
5	680
5	794
5	650
5	780
5	442
5	372
5	627
5	882
5	756
5	548
5	767
5	745
6	759
6	665
6	730
6	930
6	369

Day	Patient Time
6	635
6	313
6	843
6	264
6	663
6	991
6	431
7	372
7	835
7	884
7	930
7	667
7	747
7	390
7	644
7	339
7	664
7	245
7	893
8	370
8	294
8	480
8	558
8	502
8	595
8	847
8	544
8	853
8	876
8	744
8	816
9	530
9	881
9	943
9	383

Day	Patient Time
9	316
9	611
9	778
9	531
9	896
9	772
9	719
9	670
10	494
10	914
10	870
10	272
10	662
10	348
10	447
10	306
10	751
10	445
10	717
10	387
11	659
11	919
11	603
11	897
11	319
11	499
11	799
11	482
11	615
11	497
11	430
11	765
12	274
12	754
12	428

Day	Patient Time
12	811
12	916
12	332
12	765
12	961
12	437
12	692
12	380
12	566
13	797
13	253
13	829
13	857
13	898
13	387
13	918
13	900
13	691
13	600
13	450
13	775
14	678
14	679
14	351
14	663
14	638
14	928
14	258
14	338
14	446
14	936
14	584
14	535
15	997
15	205

Day	Patient Time
15	893
15	734
15	474
15	631
15	746
15	642
15	484
15	525
15	685
15	358
16	242
16	474
16	966
16	823
16	515
16	617
16	894
16	519
16	636
16	547
16	993
16	858
17	594
17	817
17	381
17	462
17	429
17	786
17	901
17	278
17	472
17	885
17	991
17	557
18	368

Day	Patient Time
18	850
18	510
18	688
18	201
18	795
18	977
18	715
18	253
18	310
18	412
18	813
19	806
19	575
19	348
19	298
19	487
19	697
19	249
19	668
19	533
19	985
19	284
19	707
20	497
20	785
20	806
20	263
20	435
20	337
20	659
20	537
20	786
20	607
20	466
20	564

Answer:

The bottom portion in Figure 18.5 is the S chart, and the top portion is the X Bar chart. First, the S chart is examined for signs of special variation. None of the points on the S chart is outside the control limits, and there are no other signals indicating a lack of control. Thus, there are no indications of special sources of variation on the S chart. Now the X Bar chart can be examined. There are no indications of a lack of control, so the process can be considered to be stable and the output predictable with respect to time as long as conditions remain the same. The next step is to reduce the common causes of variation in the process.

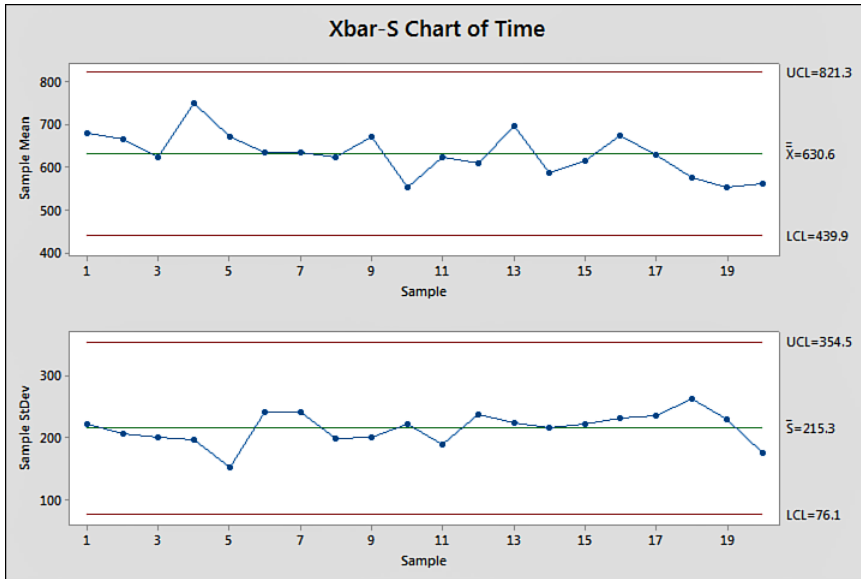


Figure 18.5 X Bar and s chart of the vial weights for six vials selected during 22 time periods

Question: Construct and interpret a Gage R&R run chart from the following data. Two inspectors independently use a light gage to measure each of five units four separate times; this results in 40 measurements. The data to be collected by the five inspectors is shown in Table 18.7.

Table 18.7 Data for Gage R&R Study

Random Order	Standard Order	Unit	Inspector	Measure
1	36	5	Enya	21.85
2	5	1	Lucy	21.19
3	30	4	Lucy	23.14
4	29	4	Lucy	23.09

Random Order	Standard Order	Unit	Inspector	Measure
5	26	4	Enya	23.28
6	28	4	Enya	23.23
7	6	1	Lucy	21.29
8	8	1	Lucy	21.24
9	4	1	Enya	21.24
10	3	1	Enya	21.33
11	18	3	Enya	22.28
12	20	3	Enya	22.34
13	40	5	Lucy	21.78
14	9	2	Enya	21.65
15	31	4	Lucy	23.02
16	24	3	Lucy	22.17
17	38	5	Lucy	21.84
18	17	3	Enya	22.31
19	32	4	Lucy	23.19
20	11	2	Enya	21.67
21	27	4	Enya	23.24
22	19	3	Enya	22.31
23	10	2	Enya	21.60
24	33	5	Enya	21.84
25	37	5	Lucy	21.76
26	2	1	Enya	21.29
27	35	5	Enya	21.93
28	23	3	Lucy	22.14
29	13	2	Lucy	21.50
30	7	1	Lucy	21.21
31	15	2	Lucy	21.51
32	22	3	Lucy	22.23
33	14	2	Lucy	21.55
34	34	5	Enya	21.89
35	1	1	Enya	21.34
36	12	2	Enya	21.56
37	16	2	Lucy	21.55
38	39	5	Lucy	21.81
39	21	3	Lucy	22.18
40	25	4	Enya	23.27

Answer:

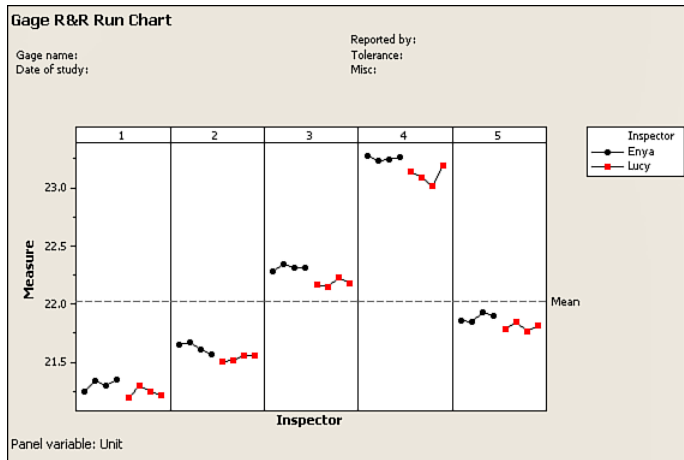


Figure 18.6 Gage R&R chart

A visual analysis (see Figure 18.6) of the data in Table 18.7 indicates that repeatability (within group variation) is good. Good reproducibility is demonstrated by the similarity of the squares connected by lines and the dots connected by lines, for each unit. Reproducibility (one form of between group variation) is good. The Gage run chart shows that most of the observed total variation in light gage readings is due to differences between units, which indicates a good measurement system.

Question: What is a flowchart, and what are two types of flowcharts?

Answer: A flowchart is a tool used to map out (draw a picture of) a process. There are two types of flowcharts; they are:

- **Process flowcharts**—Flowcharts that describe the steps and decision points of a process in a downward direction from the start (top of the page) to the stop (bottom of the page) of the process.
- **Deployment flowcharts**—Flowcharts organized into “lanes,” which show processes that involve various departments, people, stages, or other categories.

Question: Define Voice of the Customer (VoC), and explain the four stages of a VoC analysis.

Answer: Voice of the Customer analysis involves surveying stakeholders of a process to understand their requirements and needs. Stakeholders can include customers, employees, investors, regulatory agencies, building and grounds, the legal system, and the environment, to name a few possible stakeholders of a process.

There are typically four stages when conducting the Voice of the Customer analysis:

1. Define/segment the market. (Identify the stakeholder groups.)
2. Plan the VoC. (Identify who will be interviewed and who will interview them, establish a time schedule, and prepare the questions.)
3. Collect the data by stakeholder group.
4. Organize and interpret the data.

Question: What is a SIPOC analysis? Give an example of one.

Answer: A SIPOC analysis is a simple tool for identifying the Suppliers and their Inputs into a process, the high level steps of a Process, the Outputs of the process, and the Customer segments interested in the outputs of the process.

Table 18.8 is an example of a SIPOC analysis for the patient scheduling process at an outpatient clinic in a hospital.

Table 18.8 SIPOC Analysis

Process Name: Patient Scheduling Process in the Outpatient Clinic at XYZ Hospital				
Process Owner: Assistant Vice President of Outpatient Services				
SUPPLIERS (Providers of required resources)	INPUTS (Resources required by the process)	PROCESS	OUTPUTS (Deliverables from the process)	CUSTOMERS (Stakeholders who put requirements on the outputs)
Referring physicians Patients/families Appointment schedulers Insurance providers	Referral Phone call Patient information Patient and physician availability Insurance plan	Call comes in. ↓ Patient entered into electronic medical record system. ↓ Appointment scheduled. ↓ Insurance verified. ↓ Reminder call if time. ↓ Patient either shows or no shows.	New patient record in electronic medical record system Scheduled appointment Verified insurance Reminder Arrived visit Patient no show	Patient registration reps in clinics Nurses Physicians Insurance providers Finance office Patients/families

Question: What is an operational definition and give an example of one?

Answer: An operational definition promotes understanding between people by putting communicable meaning into words. An operational definition contains three parts: a criterion to be applied to an object or group, a test of the object or group, and a decision as to whether the object or group meets the criterion.

- **Criteria**—Operational definitions establish Voice of the Customer specifications for each CTQ that will be compared with the Voice of the Process outputs in the Test step of an operational definition.
- **Test**—A test involves comparing Voice of the Process data with Voice of the Customer specifications for each CTQ, for a given unit of output.
- **Decision**—A decision involves making a determination whether a given unit of output meets Voice of the Customer specifications.

Example:

Susan lends Mary her coat for a vacation. Susan requests that it be returned clean. Mary returns it dirty. Is there a problem? Yes! What is it? Susan and Mary failed to operationally define clean. They have different definitions of clean. Failing to operationally define terms can lead to problems. A possible operational definition of clean is that Mary will get the coat dry-cleaned before returning it to Susan. This is an acceptable definition if both parties agree. This operational definition is shown here:

Criteria: The coat is dry-cleaned and returned to Susan.

Test: Susan determines whether the coat was dry-cleaned.

Decision: If the coat was dry-cleaned, Susan accepts the coat. If the coat was not dry-cleaned, Susan does not accept the coat.

Question: Give an example of an FMEA.

Answer:

Table 18.9 No Shows Six Sigma Project Failure Modes and Effects Analysis

Critical Parameter	Potential Failure				Current Controls				Responsibility and Date Action Taken						
	Failure Mode	Failure Effect	SEV	Potential Causes	OCC	Controls	DET	RPN	Recommended Action	Target Date	Date Action Taken	SEV	OCC	DET	RPN
Lack of buy-in by top management.	Project doesn't get supported.	Project unexecutable.	10	Lack of commitment.	10	None.	10	1000	Top management must have skin in the game.	CEO	6/2/2019	2	4	10	80
Project exceeds budget.	Black Belt gets fired!	Need to hire new BB.	3	BB lacks financial expertise.	8	BB does his best.	5	120	Finance rep on team responsible for budget.	Finance rep.	6/2/2019	2	5	5	50
Takes too long to get data.	Project is delayed.	Heads roll.	8	BB lacks IT expertise.	8	BB does his best.	5	320	IT rep on team responsible for data.	IT rep	6/2/2019	4	4	5	80
Lack of buy-in from physicians.	Implementation issues.	Unsuccessful implementation.	7	Entitled physicians.	8	Lots of bitching back and forth.	8	448	Physician Champion part of team.	Physician Champion	6/2/2019	4	6	8	192
Lack of buy-in from nurses.	Implementation issues.	Unsuccessful implementation.	7	Entitled physicians.	8	Lots of bitching back and forth.	8	448	Nursing Champion part of team.	Nursing Champion	6/2/2019	4	6	8	192
Lack of awareness.	Lack of cooperation.	Misaligned team.	5	Lack of communication.	5	Rumor mill in overdrive.	2	50	Communication plan created.	Black Belt	6/2/2019	1	5	2	10
Scope too broad.	Project becomes unmanageable.	Project unexecutable.	7	Trying to boil the ocean.	7	Planning by Black Belt.	3	147	Strong planning effort by Black Belt.	Black Belt	6/2/2019	3	3	3	27

Question: What is the purpose of a Pareto diagram and give an example of one?

Answer: Pareto diagrams are used to identify and prioritize issues that contribute to a problem; a Pareto diagram is mainly a prioritization tool. The Pareto principle is frequently called the 80-20 rule; 80% of your problems come from 20% of your potential causes. Pareto analysis focuses on distinguishing the vital few significant causes of problems from the trivial many causes of problems. The vital few are the few causes that account for the largest percentage of the problem (e.g., 80%), while the trivial many are the myriad of causes that account for a small percentage of the problem (e.g., 20%). The causes of the problem become Xs, and the problem is the CTQ(s).

Example:

The director of a hospital pharmacy is interested in learning about the reasons on delays to orders for the hospital's chemotherapy treatment unit. He collects data for a month on the reasons for delays that are seen Table 18.10. Figure 18.7 shows the resulting Pareto diagram.

Table 18.10 Pharmacy Delay Reasons

Delay Reason	Number
Missing D.O.S.	74
Missing height and weight	66
Dose change	15
Order clarification	9
No consent form	7
Labs pending	6
Labs high	2

Missing D.O.S. and missing height and weight account for 78.2% of the problems. These two issues should be addressed first.

Question: What are change concepts and what are their groupings?

Answer: Change concepts are approaches to changing the Xs (steps in a process flowchart) that have been found to be useful in developing solutions that lead to improvements in processes. By creatively combining these change concepts with process knowledge, teams can develop changes that lead to substantial improvement. The 70 change concepts are organized into the following nine general groupings:

Grouping	Number of Concepts in Grouping
A. Eliminate waste	11
B. Improve work flow	11
C. Optimize inventory	4
D. Change the work environment	11
E. Enhance the producer/customer relationships	8
F. Manage time	5

Grouping	Number of Concepts in Grouping
G. Manage variation	8
H. Design systems to avoid mistakes	4
I. Focus on the product/service	8

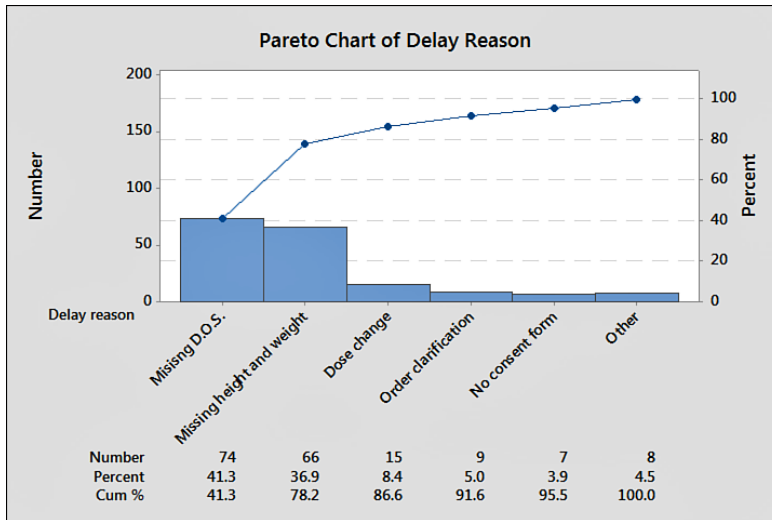


Figure 18.7 Delay reasons Pareto diagram

Missing D.O.S. and missing height and weight account for 78.2% of the problems. These two issues should be addressed first.

Question: What is a communication plan and are they needed?

Answer: A communication plan is created for a project to identify, inform, and appease concerns regarding a process improvement event because many people will typically be affected by it.

Implementing new processes typically involves the need for employees to change their behaviors. Having a communication plan allows the team to be proactive in informing people in the organization as to what is going on so there are no surprises and so no one is caught off guard when it is time to implement solutions.

Question: Explain the purpose and four steps of the SDSA cycle.

Answer: The SDSA cycle is a series of four steps used to standardize a process and reduce variation in process outcomes. After forming a project team, determining a process to standardize, and agreeing on a way to measure success, the following steps are executed.

- **Standardize**—Each employee flowcharts the process under study; usually their job. They are then brought together and agree upon a best practice flowchart that takes the best aspect of their individual flowcharts and eliminates the worst aspects of their individual flowcharts. Basically they move from their individual current state flowcharts to a new, and hopefully improved, standardized future state flowchart that all employees using the flowchart agree upon and follow. Standardization can dramatically reduce variability in the outcomes of a process. It is also a great test of a workforce’s ability to exhibit discipline in the way they do their jobs. Personal discipline to follow the standardized flowchart, or an improved flowchart, is *critical* to a successful Six Sigma organizational transformation.
- **Do**—Each employee uses the new, standardized flowchart, and they collectively gather data of their efforts so the results can be analyzed in the Study step.
- **Study**—Employees analyze the results of the experiment or test on the new standardized flowchart to see whether it had the intended outcome.
- **Act**—Employees decide whether to adopt the new standardized flowchart, and if the answer is yes, they lock it in with documentation and training, or modify the plan and repeat the SDSA cycle. If the answer is no, the team goes back to the beginning and tries again.

Question: Explain the purpose and four steps of the PDSA cycle.

Answer: The PDSA cycle is used to continually improve a process by reducing variation, centering the mean on the desired nominal level, or eliminating waste from the process. After forming a project team, determining an aim for the team, and agreeing on a way to measure success (a metric), the following steps are executed:

- **Plan**—Team members figure out what changes can be made to the current best practice process (see standardized flowchart on the left of the Figure 18.8) to achieve improved results from the revised best practice method for the metric of interest (see revised practice flowchart on the right of Figure 18.8)—for example, deleting an unnecessary step in the process as shown in Figure 18.8. Basically, team members are moving from the current state flowchart to a new, and hopefully, improved future state flowchart by changing the flow of the process.
- **Do**—Next, team members conduct an experiment, or test of the revised flowchart (Plan) on a small scale and collect data so the results can be analyzed in the Study step.
- **Study**—Team members, perhaps with the assistance of an expert, analyze the results of the experiment or determine whether it had the intended outcome.
- **Act**—Team members decide whether to (1) adopt the revised best practice flowchart and lock it in with documentation and training, (2) abandon the revised best practice method because it failed to yield the desired results, or (3) modify the revised best practice method and repeat the PDSA cycle.

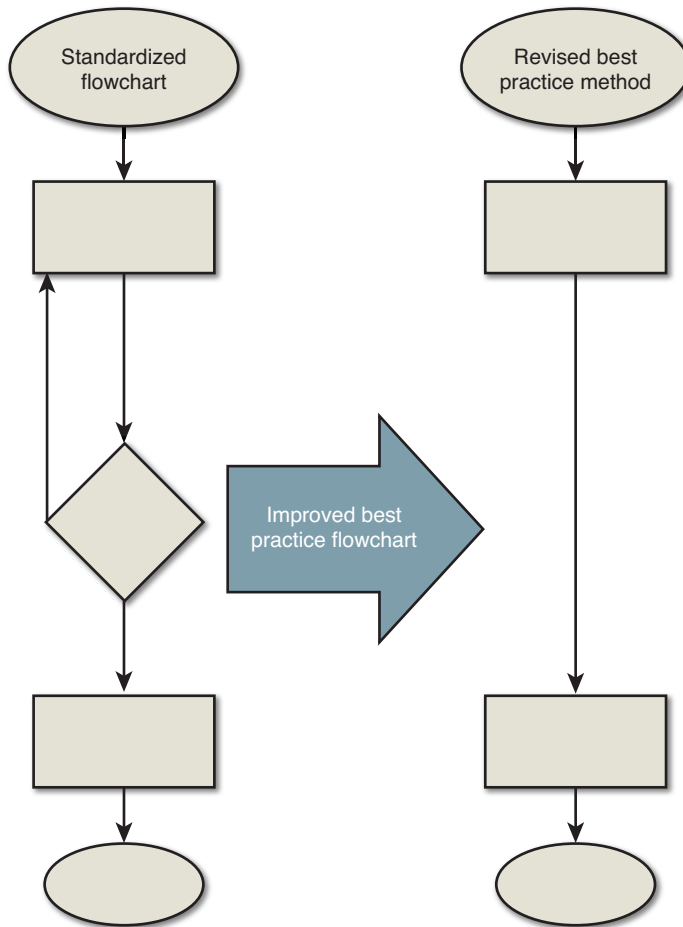


Figure 18.8 Standardized and revised best practice flowcharts

Question: Explain how Kaizen works.

Answer: Kaizen works as follows: The PDCA cycle is turned, and at the Do stage employees make small and rapid modifications to the Plan stage and determine their success in the Study phase of the PDCA cycle. The small and rapid changes to the plan find any problems with the plan, display the problems, clear the problems that stand in the way of the plan, and acknowledge the correctness of the modification to the plan. Next, employees study the results of the effort by viewing the critical metric (CTQ), and finally, act. Kaizen or Rapid Improvement Events are typically conducted on processes where the root cause is known but the solution to eliminate the root cause is not.

Question: Explain the purpose of the DMAIC model.

Answer: The easiest way to explain the DMAIC model is to think of it in terms of the CTQ (Y) is a function of one or more Xs. For example, suppose that it is believed that patient waiting time is affected by insurance type, physician, and availability of an examination room. This could be stated as follows:

Patient waiting time is a function of insurance type, physician, and availability of an examination room.

If we call Patient waiting time CTQ, insurance type (X_1), physician (X_2), and availability of an examination room (X_3), then we can write the relationship between the CTQ and the Xs as follows:

$$CTQ = f(X_1, X_2, X_3)$$

where:

- CTQ is a measure of patient waiting time.
- f is the symbol of relationship.
- X_1 is insurance type.
- X_2 is physician.
- X_3 is availability of an examination room.

The five phases of the DMAIC model are Define, Measure, Analyze, Improve, and Control. They are aimed at finding change concepts that will modify how the Xs are performed with the intention of moving the CTQ (Y) in a specified direction, reducing variation in the output (Y), or both.

Question: Construct and explain the structure of a dashboard.

Answer:

Table 18.11 Generic Managerial Dashboard

Mission Statement: A mission statement is a declaration of the reason for the existence of an organization. It should be short and memorable, as well as noble and motivational.				
President		Direct Reports		Potential Process Improvement Projects or Tasks
Presidential Objectives	Presidential Indicators	Area Objectives	Area Indicators	
Presidential objectives that must be achieved to attain the mission statement.	A key indicator is a measurement that monitors the status of a key objective. One or more presidential indicators show progress toward each presidential objective.	Area objectives are established to move each presidential indicator in the proper direction.	One or more area indicators show progress toward each area objective.	Process improvement projects or tasks are used to improve or innovate processes to move indicators in the proper direction.

Question: Give an example of a matrix that could be used to prioritize potential Six Sigma projects. Explain how the matrix works.

Answer:

Table 18.12 Project Prioritization Matrix

Evaluation Criteria	Weight	Project A	Project B	Project C	Project D
Criteria 1	Weight 1				
Criteria 2	Weight 2				
Criteria 3	Weight 3				
Criteria 4	Weight 4				
Criteria 5	Weight 5				
Criteria 6	Weight 6				
Weighted average of potential projects					

In Table 18.12, the cell values are assigned by top management, and they evaluate the strength of the relationship between each criteria and each potential project.

They are defined as follows:

- 0 = no relationship between criteria and project
- 1 = weak relationship between criteria and project
- 3 = moderate relationship between criteria and project
- 9 = strong relationship between criteria and project

Each cell value is then multiplied by its respective weight and summed so that each potential project has a weighted average. The projects are then prioritized by weight, which ranks them in terms of importance to the organization based on the evaluation criteria. Obviously this is not an exact science and is subjective in nature, so it is still possible that management will make an executive decision to go with a project that is lower on the list due to reasons they deem important.

Question: What is the non-technical definition of Six Sigma?

Answer: Six Sigma management can be defined as the relentless and rigorous pursuit of the reduction of variation in all critical processes to achieve continuous and breakthrough improvements that impact the bottom-line and/or top-line of the organization and increase customer satisfaction.

Question: What is the technical definition of Six Sigma management, which can be used to explain why a Six Sigma process generates no more than 3.4 defects per million opportunities. Make sure to draw a picture to explain your answer.

Answer: Figure 18.9 shows a Six Sigma process with a 1.5 sigma shift in the mean. As you can see, the upper tail of the shifted distributions doesn't come close to the specification limit. Consequently, there is likely to be no more than 3.4 defects per million opportunities, at the nearest specification limit.

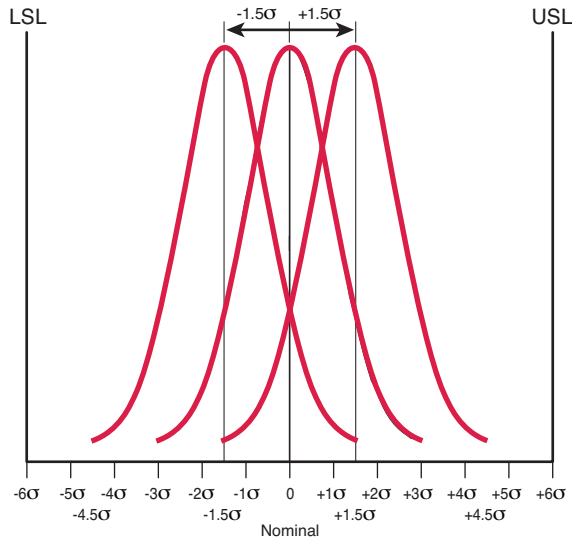


Figure 18.9 Six Sigma process with 1.5 sigma shift in the mean

Question: What is the purpose of Deming's theory of management?

Answer: Deming believed that joy in work will “unleash the power of human resource contained in intrinsic motivation.”

Question: What are the 4 paradigms of Deming's theory of management?

Answer:

Paradigm 1. People are best inspired by a mix of intrinsic and extrinsic motivation, not only by extrinsic motivation.

Paradigm 2. Manage using both a process and results orientation, not only a results orientation. Management's job is to improve and innovate the processes that create results, not just to manage results.

Paradigm 3. Management's function is to optimize the entire system so that everyone wins, not to maximize only their component of the system.

Paradigm 4. Cooperation works better than competition, if the aim of the system is not to win.