Notes-Control Charts/Out Of Control Signs

1) We must know the mean and standards deviation.
2) We must know that the long run distribution is normal or the control chart in not relevant.
3) Place horizontal lines at μ , $\mu \pm 2\sigma$ and $\mu \pm 3\sigma$
4) Then we simply plot each data value according to the number of deviations it is from the mean.

Example: In this distribution Ms Tamara work for the Antlers Lodge cleaning rooms. Once customers have checked out Ms Tamara goes in to clean up. He goal is to have all rooms ready for the next customer by 4:00pm. Her administrators record the number of rooms not made up by 3:30 pm daily. The distribution of unmade rooms is approximately normal with mean $\mu = 19.3$ and $\sigma = 4.7$. This distribution of x values is acceptable by her administrators.

Here is the data from a 15 day period

Day	1	2	3	4	5	6	7	8
x = number of rooms	11	20	25	23	16	19	8	25
Day	9	10	11	12	13	14	15	
x = number of rooms	17	20	23	29	18	14	10	

<u>***Out of Control Sign Recognizable from Control Chart***</u>

1)

Out-of-Control Signal I: *One point falls beyond the 3σ level.* What is the probability signal I will be a false alarm? By the empirical rule, the probability that a point lies within 3σ of the mean is 0.997. The probability that signal I will give a false alarm is $1 - 0.997 = 0.003$. Remember, a false alarm means that the x distribution is really on the target distribution, and we simply have a very rare (probability of 0.003) event. (See Figure 6-10a.)

2)

Out-of-Control Signal II: *A run of nine consecutive points on one side of the center line (the line at target value μ).* What is the probability that signal II is a false alarm? If the x distribution and the target distribution are the same, then there is a 50% chance that any x values will lie above or below the center line at μ. Because the samples are (time) independent, the probability of a run of nine points on one side of the center line is $(0.5)^9 = 0.002$. If we consider both sides, this probability becomes 0.004. Therefore, the probability that signal II is a false alarm is approximately 0.004. (See Figure 6-10b.)

3)

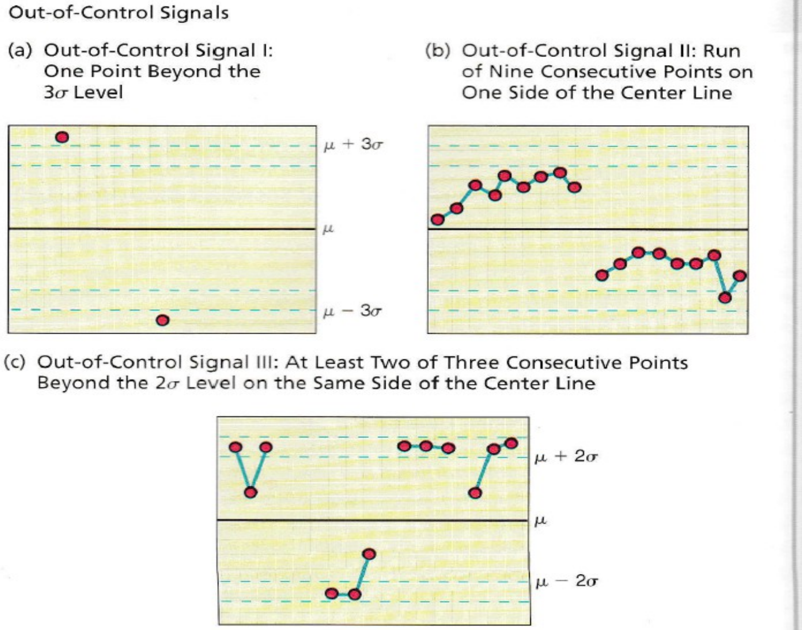
Out-of-Control Signal III: *At least two of three consecutive points lie beyond the 2σ level on the same side of the center line.* What is the probability that signal III will produce a false alarm? By the empirical rule, the probability that an x value will lie above the 2σ level is about 0.023. If we use the binomial probability distribution (with success being the point is above 2σ), then the probability of two or more successes out of three trials is

$$\frac{3!}{2!1!}(0.023)^2(0.977) + \frac{3!}{3!0!}(0.023)^3 \approx 0.002$$

If we take into account *both* above or below the center line, it follows that the probability that signal III is a false alarm is about 0.004. (See Figure 6-10c.)

FIGURE 6-10

Out-of-Control Signals



Type of Warning Signal	Probability of a False Alarm
Type I: Point beyond 3σ	0.003
Type II: Run of nine consecutive points all below center line μ or all above center line μ	0.004
Type III: At least two out of three consecutive points beyond 2σ	0.004

Remember, a control chart is only a warning device, and it is possible to get a false alarm. A false alarm happens when one (or more) of the out-of-control signals occurs, but the x distribution is really on the target or assigned distribution. In this case, we simply have a rare event (probability of 0.003 or 0.004). In practice, whenever a control chart indicates that a process is out of control, it is usually a good precaution to examine what is going on. If the process is out of control, corrective steps can be taken before things get a lot worse. The rare false alarm is a small price to pay if we can avert what might become real trouble.

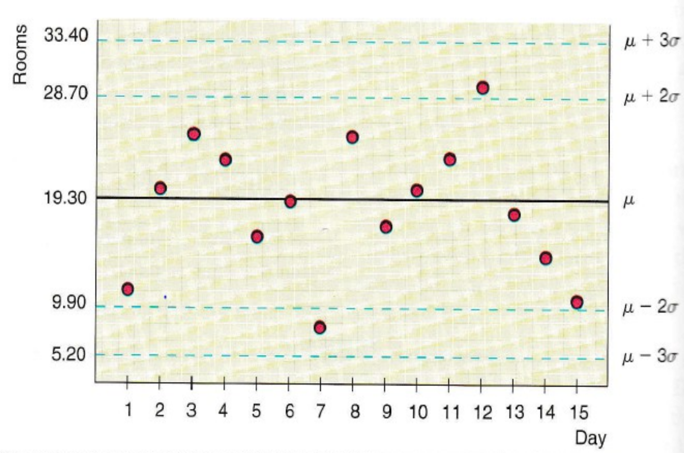
From an intuitive point of view, signal I could be thought of as a blowup, something dramatically out of control. Signal II could be thought of as a slow drift out of control. Signal III is between a blowup and a slow drift.

Practice

Ms Tamara of the Antlers Lodge examines the control chart for housekeeping. During the staff meeting, she makes recommendations about improving service, or if all is going well, she gives her staff a well-deserved "pat on the back." The most recent control chart for housekeeping is the one shown in Figure 6-11 on the next page. Look at this control chart to determine if the housekeeping process is out of control or not.

FIGURE 6-11

Number of Rooms not Made Up by 3:30 P.M.



SOLUTION: The x values are more or less evenly distributed about the mean $\mu = 19.3$. None of the points are outside the $\mu \pm 3\sigma$ limit (i.e., above 33.40 or below 5.20 rooms). There is no run of nine consecutive points above or below μ. No two of three consecutive points are beyond the $\mu \pm 2\sigma$ limit (i.e., above 28.7 or below 9.90 rooms).

It appears that the x distribution is "in control." At the staff meeting, Ms Tamara should tell her employees they are doing a reasonably good job and that they should keep up the fine work! ◇

Over the next 15-day period, let's suppose that housekeeping again reported the number of rooms not made up by 3:30 P.M. to Ms Tamara of the Antlers Lodge. The data in Table 6-2 show the results.

TABLE 6-2 Next 15-Day Report of Rooms not Made Up by 3:30 P.M.

Day	1	2	3	4	5	6	7	8
x = number of rooms	25	8	23	15	26	24	31	21
Day	9	10	11	12	13	14	15	
x = number of rooms	27	20	25	21	27	11	16	

(a) We assume that we are still working with the symmetrical, bell-shaped distribution of x values, with mean $\mu = 19.3$ and $\sigma = 4.7$. Compute the "control limits" of $\mu \pm 2\sigma$ and $\mu \pm 3\sigma$. Draw a control chart showing the solid line at the mean and the dashed lines at the control limits. Plot the data for the 15-day period.

(b) Interpret the control chart of part (a).

TABLE 6-3 3rd Housekeeping Data Report

Day	1	2	3	4	5	6	7	8
Number of rooms	29	14	18	21	11	20	35	24
Day	9	10	11	12	13	14	15	
Number of rooms	19	12	19	6	8	11	20	

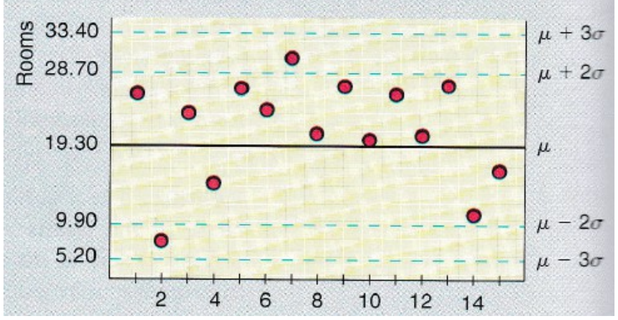
(c) Over another 15-day period Ms Tamara obtained the data shown in Table 6-3 for housekeeping. Make a control chart using target values. $\mu = 19.3$ and $\sigma = 4.7$.

(d) Interpret the control chart of part (c).

Solutions

a)

FIGURE 6-12 Next 15-Day Report of Rooms not Made Up by 3:30 P.M.

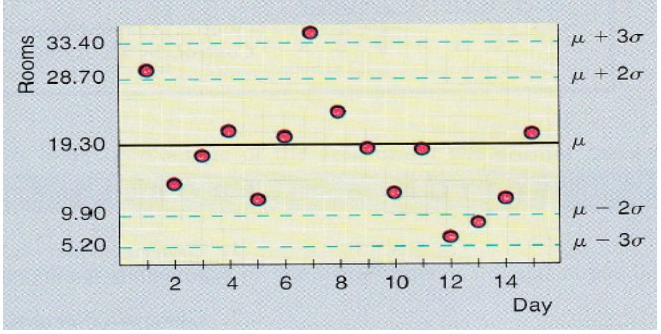


b)

Days 5 to 13 are above $\mu = 19.3$. We have nine consecutive days on one side of the mean. This is a warning signal! It would appear that the mean μ is slowly drifting up beyond the target value of 19.3. The chart indicates that housekeeping is "out of control." Ms Tamara should take corrective measures at her next staff meeting.

c)

FIGURE 6-13 3rd Housekeeping Data Report



d)

On day 7 we have a data value beyond $\mu + 3\sigma$ (i.e., above 33.40). On days 11, 12, and 13 we have two of three data values beyond $\mu - 2\sigma$. (i.e., below 9.90). The occurrences on both these periods are out-of-control warning signals. Ms Tamara might ask her staff about both these periods. There may be a lesson to be learned about day 7 when housekeeping apparently had a lot of trouble. Also, days 11, 12, and 13 were very good days. Perhaps a lesson could be learned about why things went so well.

Homework Name______________________

1. *Pain Management: Laser Therapy* "Effect of Helium-Neon Laser Auriculotherapy on Experimental Pain Threshold" is the title of an article in the journal *Physical Therapy* (Vol. 70, No. 1, pp. 24–30). In this article, laser therapy was discussed as a useful alternative to drugs in pain management of chronically ill patients. To measure pain threshold, a machine was used that delivered low-voltage direct current to different parts of the body (wrist, neck, and back). The machine measured current in milliamperes (mA). The pretreatment experimental group in the study had an average threshold of pain (pain was first detectable) at $\mu = 3.15$ mA with standard deviation $\sigma = 1.45$ mA. Assume that the distribution of threshold pain so measured in milliamperes is symmetrical and more or less mound-shaped. Use the empirical rule to
   (a) estimate a range of milliamperes centered about the mean in which about 68% of the experimental group will have a threshold of pain.
   (b) estimate a range of milliamperes centered about the mean in which about 95% of the experimental group will have a threshold of pain.

2. *Control Charts: Yellowstone National Park* Yellowstone Park Medical Services (YPMS) provides emergency health care for park visitors. Such health care includes treatment for everything from indigestion and sunburn to more serious injuries. A recent issue of *Yellowstone Today* (National Park Service Publication) indicated that the average number of visitors treated each day by YPMS was 21.7. The estimated standard deviation was 4.2 (summer data). The distribution of numbers treated is approximately mound-shaped and symmetrical.
   (a) For a 10-day summer period, the following data show the number of visitors treated each day by YPMS:

Day	1	2	3	4	5	6	7	8	9	10
Number treated	25	19	17	15	20	24	30	19	16	23

   Make a control chart for the daily number of visitors treated by YPMS, and plot the data on the control chart. Do the data indicate that the number of visitors treated by YPMS is "in control"? Explain your answer.
   (b) For another 10-day summer period, the following data were obtained:

Day	1	2	3	4	5	6	7	8	9	10
Number treated	20	15	12	21	24	28	32	36	35	37

3)

Make a control chart, and plot the data on the chart. Do the data indicate that the number of visitors treated by YPMS is "in control" or "out of control"? Explain your answer. Identify all out-of-control signals by type (I, II, or III). If you were the park superintendent, do you think YPMS might need some (temporary) extra help? Explain.

Control Charts: Motel Rooms The manager of Motel 11 has 316 rooms in Palo Alto, California. From observation over a long time, she knows that on an average night 268 rooms will be rented. The long-term standard deviation is 12 rooms. This distribution is approximately mound-shaped and symmetrical.

(a) For 10 consecutive nights, the following number of rooms were rented each night:

Night	1	2	3	4	5	6
Number of rooms	234	258	265	271	283	267

Night	7	8	9	10
Number of rooms	290	286	263	240

Make a control chart for the number of rooms rented each night, and plot the preceding data on the control chart. Looking at the control chart, would you say the number of rooms rented during this 10-night period has been unusually low? unusually high? about what was expected? Explain your answer. Identify all out-of-control signals by type (I, II, or III).

(b) For another 10 consecutive nights, the following number of rooms were rented each night:

Night	1	2	3	4	5	6
Number of rooms	238	245	261	269	273	250

Night	7	8	9	10
Number of rooms	241	230	215	217

Make a control chart for the number of rooms rented each night, and plot the preceding data on the control chart. Would you say the room occupancy has been high? low? or about what was expected? Explain your answer. Identify all out-of-control signals by type (I, II, or III).