Name_____ Course Number:_____ Section Number:_____

Directions: Answer the questions and solve the problems in the spaces provided, or attach paper. Use graph paper for control chart solutions, if preferred.

Provide an appropriate response.

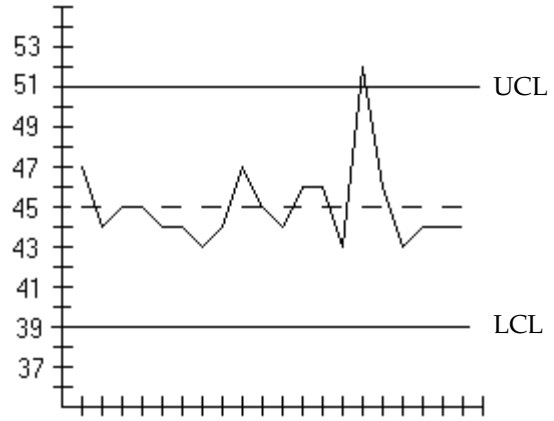
1) Define statistically stable (or "within statistical control"). Show examples of run charts which illustrate processes which are not statistically controlled. Discuss the pattern which indicates the process is not statistically controlled for each example.

2) Relate the concept of control charts to the concept of confidence intervals.

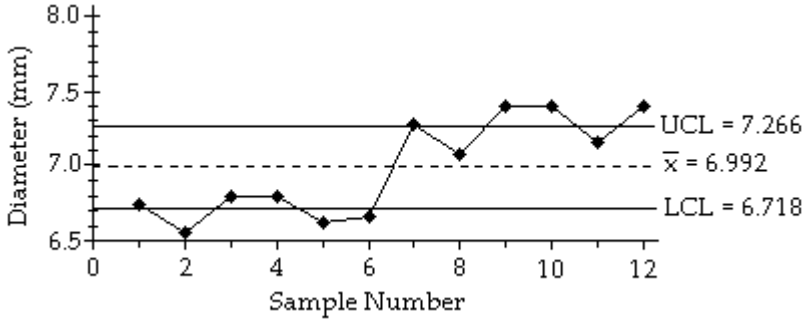
3) Describe a run chart and give an example. Refer to the values on each of the axes as you describe the run chart.

Examine the given run chart or control chart and determine whether the process is within statistical control. If it is not, identify which of the three out–of–statistical–control criteria apply.

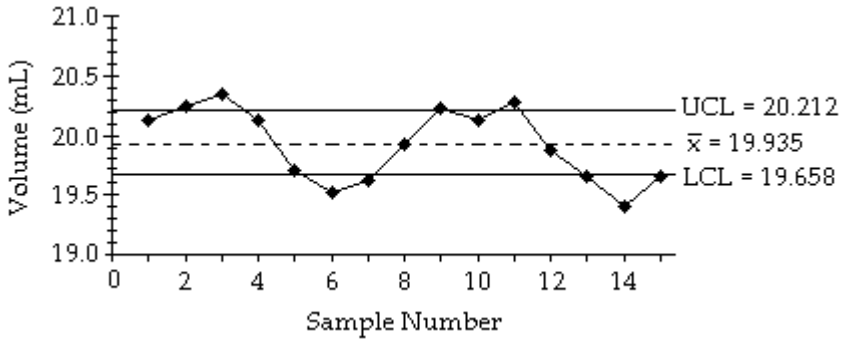
4) A control chart for $\bar{x}$ is shown below. Determine whether the process mean is within statistical control. If it is not, identify which of the three out–of–control criteria lead to rejection of a statistically stable mean.



5) A control chart for $\bar{x}$ is shown below. Determine whether the process mean is within statistical control. If it is not, identify which of the three out–of–control criteria lead to rejection of a statistically stable mean.



6) A control chart for $\bar{x}$ is shown below. Determine whether the process mean is within statistical control. If it is not, identify which of the three out–of–control criteria lead to rejection of a statistically stable mean.



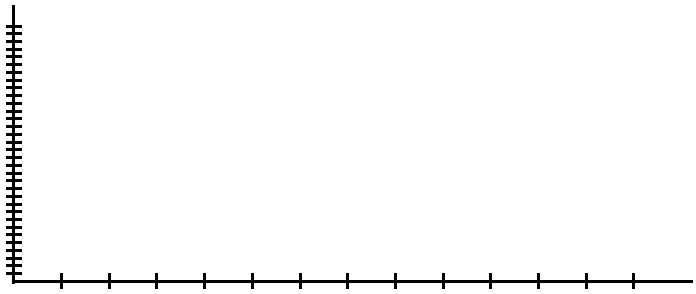
Construct an R chart and determine whether the process variation is within statistical control.

Control Chart Constants

	$\bar{x}$		s		R	
n	A_2	A_3	B_3	B_4	D_3	D_4
2	**1.880**	**2.659**	**0.000**	**3.267**	**0.000**	**3.267**
3	**1.023**	**1.954**	**0.000**	**2.568**	**0.000**	**2.574**
4	**0.729**	**1.628**	**0.000**	**2.266**	**0.000**	**2.282**
5	**0.577**	**1.427**	**0.000**	**2.089**	**0.000**	**2.114**
6	**0.483**	**1.287**	**0.030**	**1.970**	**0.000**	**2.004**
7	**0.419**	**1.182**	**0.118**	**1.882**	**0.076**	**1.924**
8	**0.373**	**1.099**	**0.185**	**1.815**	**0.136**	**1.864**
9	**0.337**	**1.032**	**0.239**	**1.761**	**0.184**	**1.816**
10	**0.308**	**0.975**	**0.284**	**1.716**	**0.223**	**1.777**

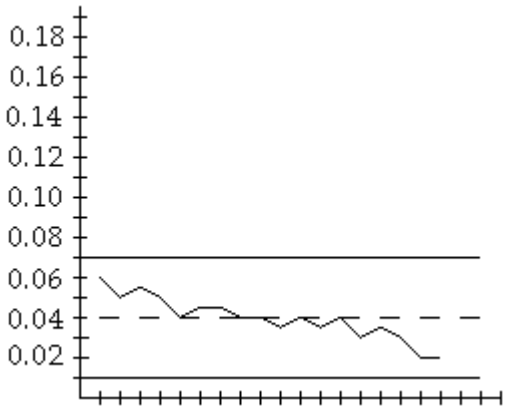
7) A machine that is supposed to produce ball bearings with a diameter of 7 millimeters yields the following data from a test of 5 ball bearings every 20 minutes.

Sample	Ball Bearing Diameter (mm)					$\bar{x}$	Range
1	6.3	6.8	6.9	6.8	6.9	6.74	0.6
2	6.3	6.6	6.6	6.3	7.0	6.56	0.7
3	6.8	6.7	7.0	6.5	7.0	6.80	0.5
4	7.0	6.7	6.7	6.8	6.8	6.80	0.3
5	6.8	6.8	6.6	6.5	6.4	6.62	0.4
6	6.8	6.7	6.6	6.3	6.9	6.66	0.6
7	7.3	7.3	7.4	7.4	7.0	7.28	0.4
8	7.2	7.0	7.2	6.9	7.1	7.08	0.3
9	7.3	7.6	7.1	7.4	7.6	7.40	0.5
10	7.2	7.6	7.5	7.6	7.1	7.40	0.5
11	7.2	7.2	7.4	7.0	7.0	7.16	0.4
12	7.5	7.4	7.4	7.6	7.1	7.40	0.5

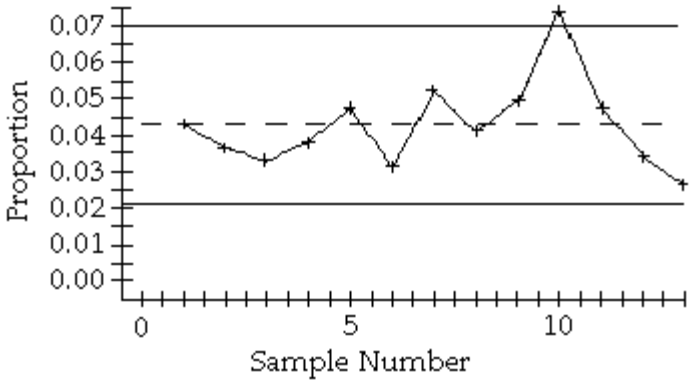


Examine the given run chart or control chart and determine whether the process is within statistical control. If it is not, identify which of the three out–of–statistical–control criteria apply.

8)



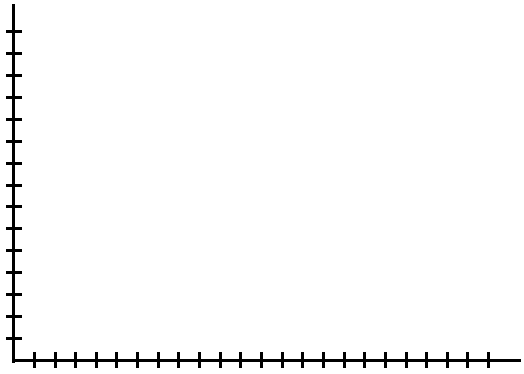
9)



Use the given process data to construct a control chart for p.

10) A drugstore considers a wait of more than 5 minutes to be a defect. Each week 100 customers are randomly selected and timed at the checkout line. The numbers of defects for 20 consecutive weeks are given below.

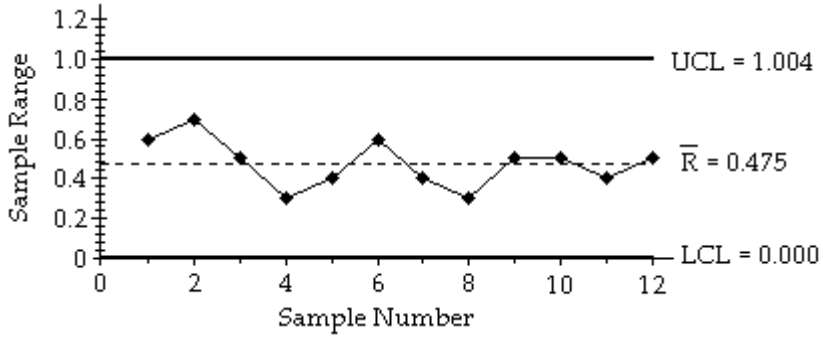
4 4 5 5 5 5 5 6 6 6 6 12 6 6 6 7 6 7 8 7



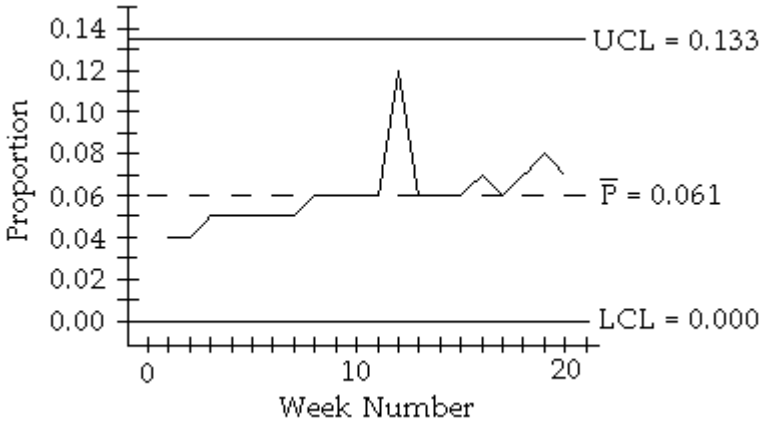
11) **Solve the problem.**
Solve the p chart. Calculate the centerline value, UCL, and LCL for a manufacturing process, whose sampling detects the following defects among 20 batches of 10,000 products per sample. Data are shown below.
6, 11, 7, 12, 9, 2, 8, 6, 12, 4, 8, 7, 4, 3, 6, 8, 10, 3, 6, 4

12) **Solve the problem.**
Solve the np chart, which is similar to the p chart, except that actual numbers of defects rather than proportions of defects are plotted on the vertical axis. For the data given in #11 above, calculate the centerline value, UCL, and LCL.

1) A process is statistically stable if it has only natural variation, with no patterns, cycles, or any unusual points. Examples that indicate the process is not statistically controlled: graphs with an obvious upward or downward trend, graphs with an upward or downward shift (relatively stable values for the first few, a shift, relatively stable values at the end), graphs with one exceptionally high or low value, graphs with cyclical behavior, or graphs whose variation is increasing over time.
2) Control charts have upper control limits and lower control limits found by processes similar to those for finding confidence intervals. Control charts allow us to examine processes to see if they remain within control, that is, within the confidence intervals.
3) A run chart is a sequential plot of individual data values over time. The horizontal axis typically is used for the time sequence, and the vertical axis is used for the values of the data. Examples will vary.
4) Process mean is not within statistical control. One of the points lies above the upper control limit.
5) Process mean is not within statistical control. There are points above and below the control limits. There is a shift upward.
6) Process mean is not within statistical control. There are points above and below the control limits. There is a cyclical pattern.
7) The process appears to be within statistical control.



8) Process is out of statistical control. There is a downward trend.
9) Process appears to be out of statistical control. There is a point that lies above the upper control limit and a downward trend.
10)



11) Centerline value = 0.00068; UCL = 0.00146; LCL = −0.000102.
12) Centerline value = 6.8; UCL = 14.62; LCL = −1.02.
[Students should discover that each np measure is n times its p counterpart.]