



# Activity 6.4d - Lego Control Charts

Name \_\_\_\_\_

## Purpose

The students will learn to plot information on average and range charts ( $\bar{X}$  (x-bar) and R charts). Learning how to use these charts is important in quality control work. Control charts are a graphic means of presenting in-process data. These charts allow us to monitor the variation of parts as they are being made and to make decisions as to when a process is out of control.

## Equipment

Dial Caliper  
Micrometer  
Excel®

## Procedure

1. Students will select 5 Lego bricks at random from a central bin.
2. Students will measure the height, width, and depth to the greatest accuracy the measuring device will allow and enter the data in the chart below.

	Height	Width	Depth	Height of Stud	Diameter of Stud
Brick 1					
Brick 2					
Brick 3					
Brick 4					
Brick 5					

3. Students will measure the diameter and height of one of the studs at the top of the block and record that data in the chart above.
4. Students working in groups of two will start Excel® and create a table similar to this one. Each group should work with a different measurement.

	A	B	C	D	E	F	G
1	Person	Sample	Block 1	Block 2	Block 3	Block 4	Block 5
2	Amy	1					
3	Billy	2					
4	Charles	3					
5	Darlene	4					

- Students will enter the dimension they are working with, gathered by the class, in the spaces for each block.
- Students should find the mean for each sample and place that in the column H. The label should read X-Bar.

fx =AVERAGE(C2:G2)							
B	C	D	E	F	G	H	
ple	Block 1	Block 2	Block 3	Block 4	Block 5	X-Bar	
1	0.625	0.626	0.625	0.625	0.624	0.625	

- Students should grab the black square in the bottom right corner of H2 and drag it down to repeat the formula for the rest of the cells.

A	B	C	D	E	F	G	H
Person	Sample	Block 1	Block 2	Block 3	Block 4	Block 5	X-Bar
Amy	1	0.625	0.626	0.625	0.625	0.624	0.625
Billy	2	0.623	0.624	0.626	0.627	0.626	
Charles	3	0.625	0.625	0.626	0.628	0.627	
Darlene	4	0.625	0.622	0.623	0.625	0.625	

- Students will write a formula to find the range of the part variation. The formula should be placed in cell L2 and read =MAX(C2:G2)-MIN(C2:G2). This will find the largest value and subtract the smallest value from it.
- Copy the formula for the other samples following steps from step 7.
- The next step is to find the average X-Bar value. Place this formula in cell J2. The formula should read =Average(H2:H20) The last H number in the formula should be the last cell you have an entry for, so it might be H18 or H27.

C	D	E	F	G	H	I	J	K	L
Block 1	Block 2	Block 3	Block 4	Block 5	X-Bar		X-Dbar		R
0.625	0.626	0.625	0.625	0.624	0.625		0.6251		0.002
0.623	0.624	0.626	0.627	0.626	0.6252				0.004
0.625	0.625	0.626	0.628	0.627	0.6262				0.003
0.625	0.622	0.623	0.625	0.625	0.624				0.003

- We cannot copy the formula as we did with previous steps as we want the same value. In Cell J3 type the formula =\$J\$2. You can copy that formula to the following cells as Excel® knows to take the value from cell J2 not the formula.

12. The next step is to find the mean of the Ranges. We will place this in Cell N2. Label the column R-Bar. The formula is =Average(L2:L21) Again the ending L value should be the last cell with an entry.

13. Copy the value to cell N3 with the formula =\$N\$2. Then copy it down the column.

fx =N\$2

C	D	E	F	G	H	I	J	K	L	M	N
Block 1	Block 2	Block 3	Block 4	Block 5	X-Bar		X-Dbar		R		R-Bar
0.625	0.626	0.625	0.625	0.624	0.625		0.6251		0.002		0.003
0.623	0.624	0.626	0.627	0.626	0.6252		0.6251		0.004		0.003
0.625	0.625	0.626	0.628	0.627	0.6262		0.6251		0.003		
0.625	0.622	0.623	0.625	0.625	0.624		0.6251		0.003		

14. This next step will establish the Upper Control Limit for our sample. We take the value from the X-Dbar column which is the mean of all the means of the sample. To this number we will add the statistical range of the samples (R-bar) times .577 which is a constant taken from the ASTM Control Chart Constants for Small Samples. The constant .577 is taken from the line for five samples on the chart for averages. The more samples you use the smaller the constant gets as there is less likelihood for errors in our samples. If you had manufactures specifications and tolerances for this part you could also use those. Label column I as UCL-X-bar In cell I2 write the formula =\$J\$2+.577\*\$N\$2.

15. Copy that value for the entire column.

fx =\$J\$2+0.577\*\$N\$2

C	D	E	F	G	H	I
Block 1	Block 2	Block 3	Block 4	Block 5	X-Bar	UCL-X-bar
0.625	0.626	0.625	0.625	0.624	0.625	0.626831
0.623	0.624	0.626	0.627	0.626	0.6252	
0.625	0.625	0.626	0.628	0.627	0.6262	
0.625	0.622	0.623	0.625	0.625	0.624	

16. Repeat the process for the Lower Control Limit in Column K, this time subtracting .577 times the Mean Range. The formula in K2 should read =\$J\$2-0.577\*\$N\$2.

17. When you are done copy the cell down the column.

18. The last step in preparing our data is to create the UCL and LCL for the Range. The LCL for Range will be 0. The UCL for range is found by multiplying the Mean of the Ranges by another constant from the charts. This time we will use the constant 2.114 which is the constant from the ASTM Control Chart for small samples. Place the label for UCL-R at the top of Column M and the formula =\$N\$2\*2.114 in cell M2. Copy the value down the column. You could also substitute the manufactures range for acceptable parts.

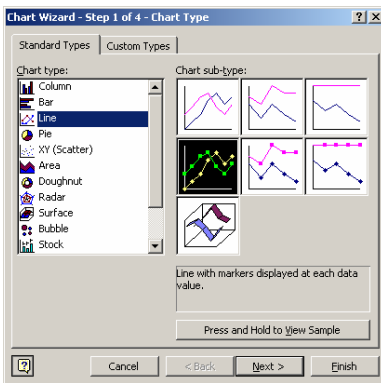
19. For the LCL-R, place the label at the top of column O and enter a 0 in cell O2. Copy the 0 down the column.

J	K	L	M	N	O
X-Dbar	LCL-X-Bar	R	UCL-R	R-Bar	LCL-R
0.6251	0.623369	0.002	0.006342	0.003	0
0.6251	0.623369	0.004	0.006342	0.003	0
0.6251	0.623369	0.003	0.006342	0.003	0
0.6251	0.623369	0.003	0.006342	0.003	0

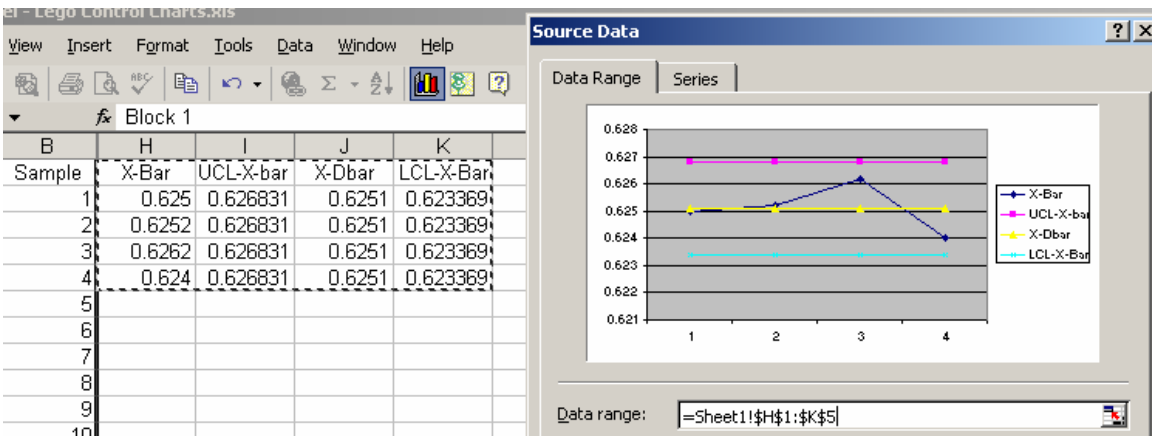
20. We can now build the X-bar and R charts. In order to make creating the table easier we will hide columns C-G. To do this left click on the letter C at the top of the column and drag across to letter G to highlight the 5 columns. Right click on one of the highlighted letters and select hide.

21. Select the Insert Chart Icon.

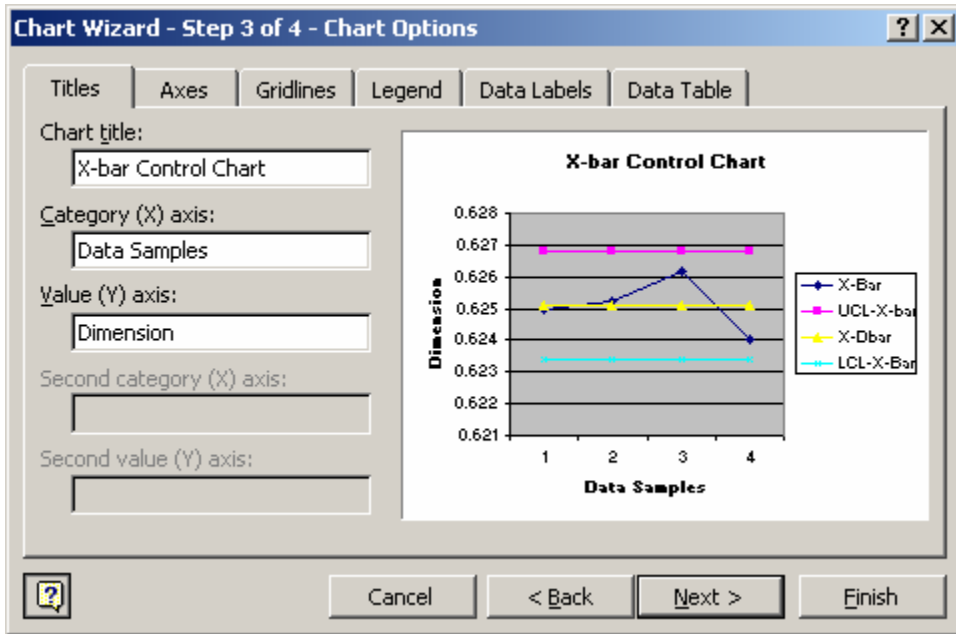
22. From the Chart Wizard select a Line Chart. Select the option for line with markers displayed at each data value.



23. Select next. When asked for data click in cell H2 and drag down to the last value in line K. Be sure the column tick box is checked on the chart dialog box.



24. After selecting next fill out the Titles tab similar to this one.



25. Select Next. For a chart location select new sheet and select finish. When the chart appears any data point that is outside the UCL and LCL lines is an example of a part that is out of control.

26. We can create the range chart in a similar fashion. Follow the directions above except you will use the data in Columns L, M, N, and O. For labels this time use the following.

