IENG484
Quality Engineering

RESEARCH ASSISTANTS

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Fall semester (2018-2019)

.Attribute Control charts (p, np, c, u) with Minitab

.Acceptance Sampling with Minitab

What is an attributes control chart?

Minitab offers several attribute control charts that plot nonconformities (defects) or nonconforming units (defectives). A nonconformity refers to a quality characteristic and a nonconforming unit refers to the overall product. A unit may have many nonconformities, but the unit itself is either conforming or nonconforming. For example, a scratch on a metal panel is a nonconformity. If several scratches exist, the entire panel may be considered nonconforming.

Select your attribute control chart based on whether your data follow a binomial or a Poisson distribution.

Attributes control charts for binomial data

Values for binomial data are classified into one of two categories such as pass/fail or go/no-go. Binomial data are often used to calculate a proportion or a percentage, such as the percentage of sampled parts that are defective.

You can use either the P chart or the NP chart to plot your nonconforming units. The main difference between P and NP charts is the vertical scale.

- P charts show the proportion of nonconforming units on the y-axis.
- NP charts show the whole number of nonconforming units on the y-axis.

The chart that you choose does not affect which points are out of control.

Attributes control charts for Poisson data

Values for Poisson data are often counts of defects or events. Poisson data are often used to model an occurrence rate, such as defects per unit.

You can use either the U chart or the C chart to plot your nonconforming units. The main difference between U and C charts is the vertical scale.

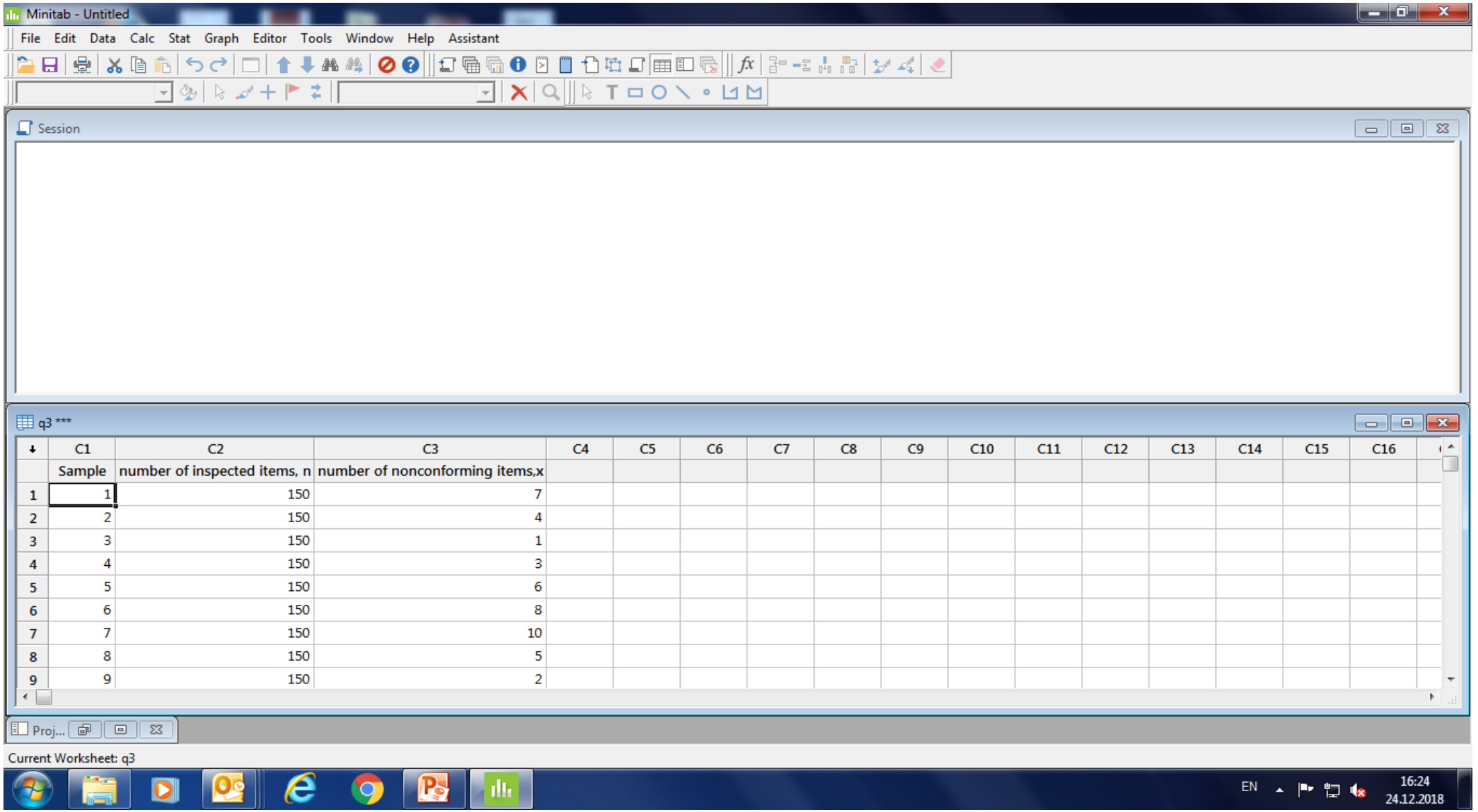
- U charts show the number of nonconformities per single unit on the y-axis.
- C charts show the number of nonconformities per sample, which can include more than one unit on the y-axis.

The chart that you choose does not affect which points are out of control.

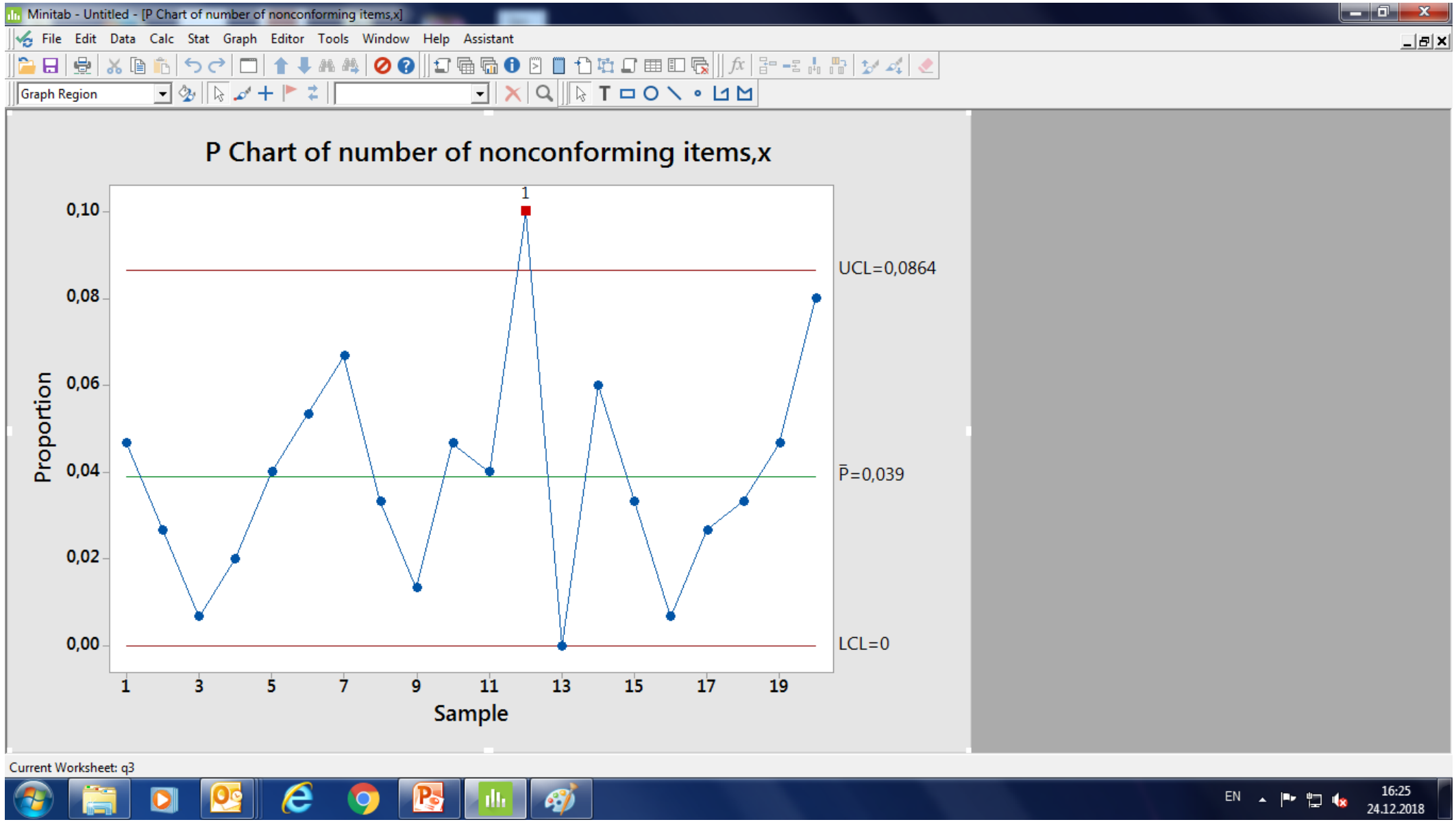
Example of P Chart

The supervisor for a call center wants to evaluate the process for answering customer phone calls. The supervisor records the total number of incoming calls and the number of unanswered calls for 20 days. The supervisor creates a P chart to monitor the proportion of unanswered calls.

1. Open the sample data IENG484-LAB3-4 from course webpage, transfer the q3 data to minitab .
2. Open the P Chart dialog box.
    - PC: STATISTICS > Control Charts > Attribute > P
    - Mac: Statistics > Attribute > P
3. In Number of defective items column, enter number of nonconforming items.
4. From the drop-down list, choose Subgroup sizes are in a column. In Subgroup sizes column, enter number of inspected items.
5. Click OK.



	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16
	Sample	number of inspected items, n	number of nonconforming items,x													
1	1	150	7													
2	2	150	4													
3	3	150	1													
4	4	150	3													
5	5	150	6													
6	6	150	8													
7	7	150	10													
8	8	150	5													
9	9	150	2													


Minitab - Untitled - [P Chart of number of nonconforming items,x]
File Edit Data Calc Stat Graph Editor Tools Window Help Assistant
Graph Region
P Chart of number of nonconforming items,x
Proportion
0,10
0,08
0,06
0,04
0,02
0,00
1
UCL=0,0864
P̄=0,039
LCL=0
1 3 5 7 9 11 13 15 17 19
Sample
Current Worksheet: q3
EN
16:25
24.12.2018

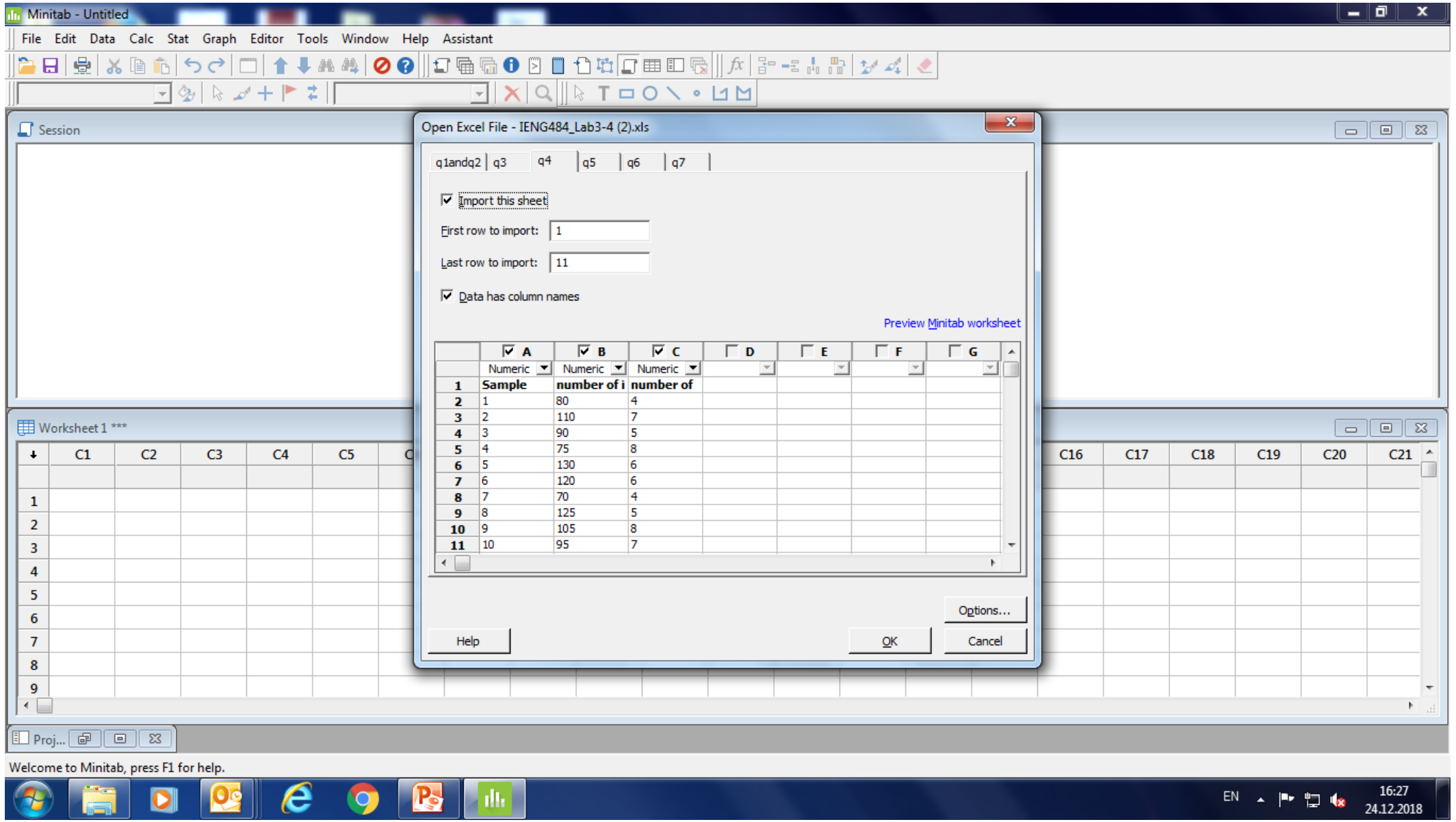
Example of NP Chart

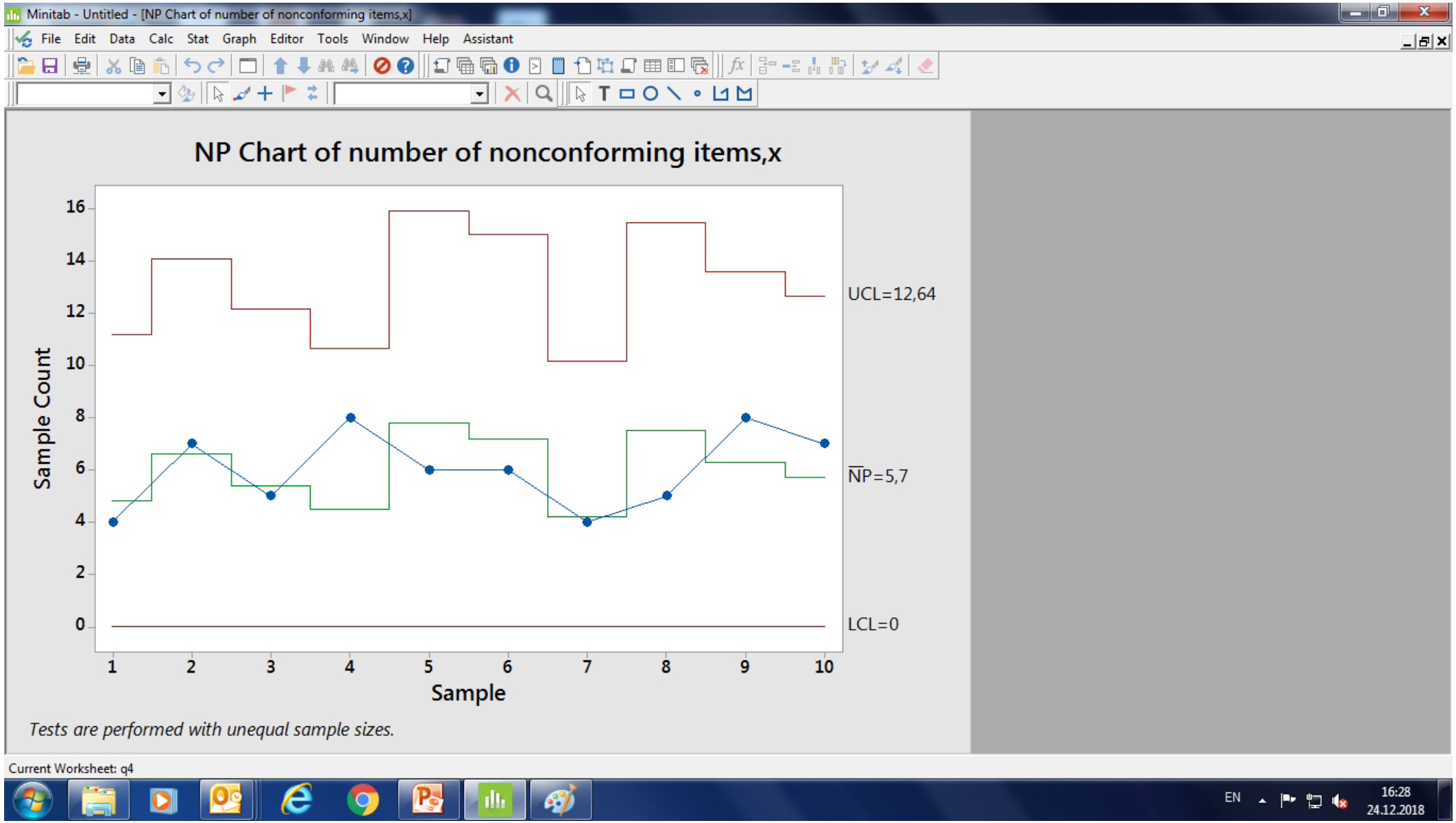
A quality engineer assesses whether the process used to manufacture light bulbs is in control. The engineer tests different lot size light bulbs each hour for 10 shifts and records the number of bulbs that did not light (defectives).

The engineer creates an NP chart to monitor the number of defective light bulbs.

1. Open the sample data, IENG484-LAB3-4 from course webpage, transfer the q4 data to minitab .
2. Choose Stat > Control Charts > Attributes Charts > NP.
3. In Variables, enter number of nonconforming items.
4. In Subgroup sizes, enter number of inspected items.
5. Click NP Chart Options.
6. On the Tests tab, select 1 point > K standard deviations from center line (Test 1) and K points in a row on same side of center line (Test 2).

   If you are not sure which tests apply in your specific situation, use Tests 1 and 2 when you first establish the control limits based on your data.
7. Click OK in each dialog box.


Minitab - Untitled
File Edit Data Calc Stat Graph Editor Tools Window Help Assistant
Session
Open Excel File - IENG484_Lab3-4 (2).xls
q1andq2 q3 q4 q5 q6 q7
Import this sheet
First row to import: 1
Last row to import: 11
Data has column names
Preview Minitab worksheet
A B C D E F G
Numeric Numeric Numeric
1 Sample number of i number of
2 1 80 4
3 2 110 7
4 3 90 5
5 4 75 8
6 5 130 6
7 6 120 6
8 7 70 4
9 8 125 5
10 9 105 8
11 10 95 7
Options...
Help
OK
Cancel
Worksheet 1 ***
C1 C2 C3 C4 C5 C16 C17 C18 C19 C20 C21
Welcome to Minitab, press F1 for help.
EN
16:27
24.12.2018


Minitab - Untitled - [NP Chart of number of nonconforming items,x]
File Edit Data Calc Stat Graph Editor Tools Window Help Assistant
NP Chart of number of nonconforming items,x
Sample Count
16
14
12
10
8
6
4
2
0
1 2 3 4 5 6 7 8 9 10
Sample
UCL=12,64
NP=5,7
LCL=0
Tests are performed with unequal sample sizes.
Current Worksheet: q4
EN
16:28
24.12.2018

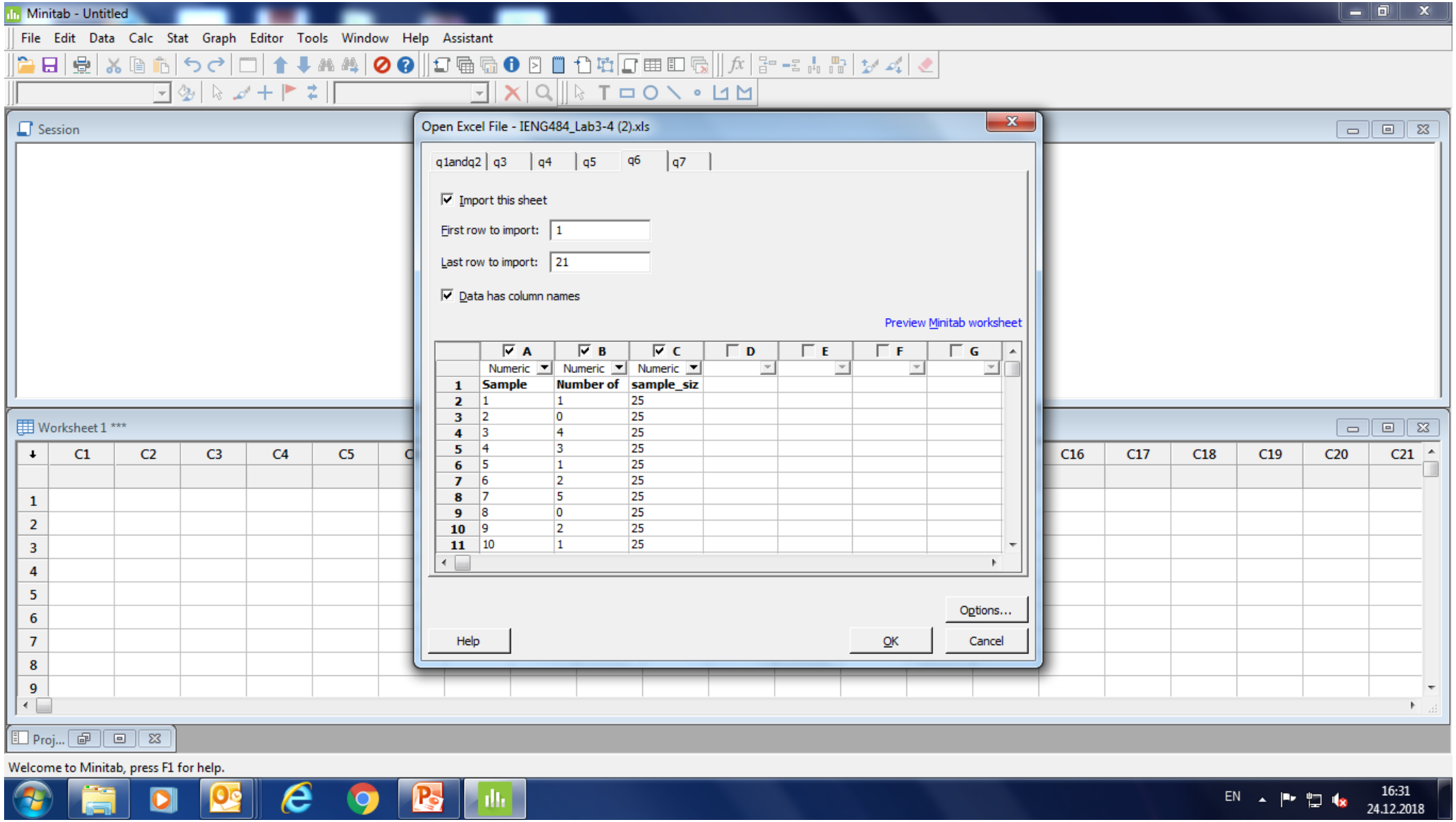
Example of C Chart

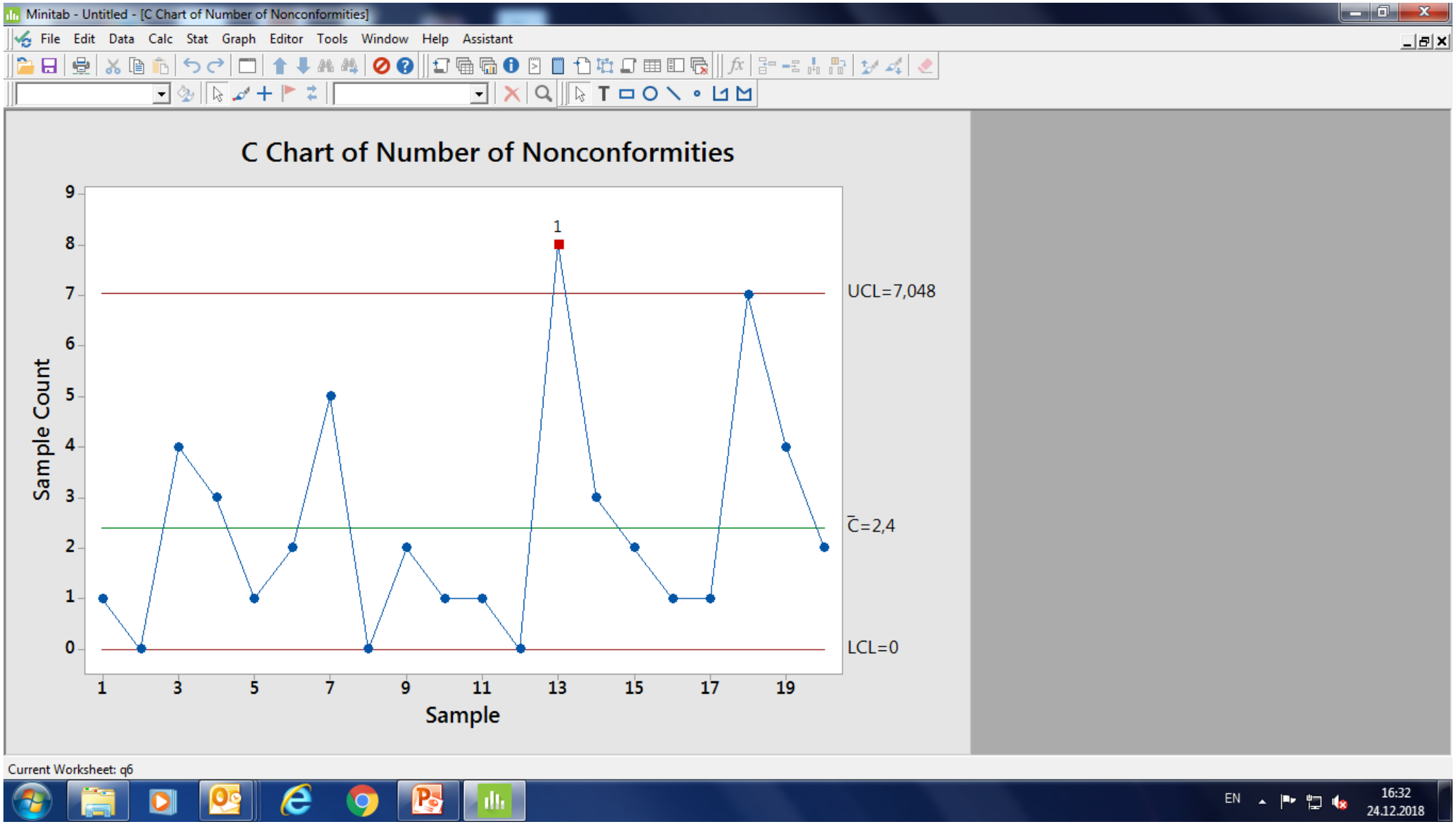
A quality engineer for a wallpaper manufacturer wants to assess the stability of the printing process.25 times, the engineer takes a sample of 100 feet of wallpaper and counts the number of printing defects, which include print smears, pattern distortions, and missing ink.

The engineer creates a C chart to monitor the number of defects.

1. Open the sample data, IENG484-LAB3-4 from course webpage, transfer the q6 data to minitab .
2. Choose Stat > Control Charts > Attributes Charts > C.
3. In Variables, enter Number of Nonconformities.
4. Click C Chart Options.
5. On the Tests tab, select 1 point > K standard deviations from center line (Test 1) and K points in a row on same side of center line (Test 2).

   If you are not sure which tests apply in your specific situation, use Tests 1 and 2 when you first establish the control limits based on your data.
6. Click OK in each dialog box.


Minitab - Untitled
File Edit Data Calc Stat Graph Editor Tools Window Help Assistant
Session
Open Excel File - IENG484_Lab3-4 (2).xls
q1andq2 q3 q4 q5 q6 q7
Import this sheet
First row to import: 1
Last row to import: 21
Data has column names
Preview Minitab worksheet
A B C D E F G
Numeric Numeric Numeric
1 Sample Number of sample_siz
2 1 1 25
3 2 0 25
4 3 4 25
5 4 3 25
6 5 1 25
7 6 2 25
8 7 5 25
9 8 0 25
10 9 2 25
11 10 1 25
Options...
Help
OK
Cancel
Worksheet 1 ***
C1 C2 C3 C4 C5 C16 C17 C18 C19 C20 C21
Welcome to Minitab, press F1 for help.
EN
16:31
24.12.2018

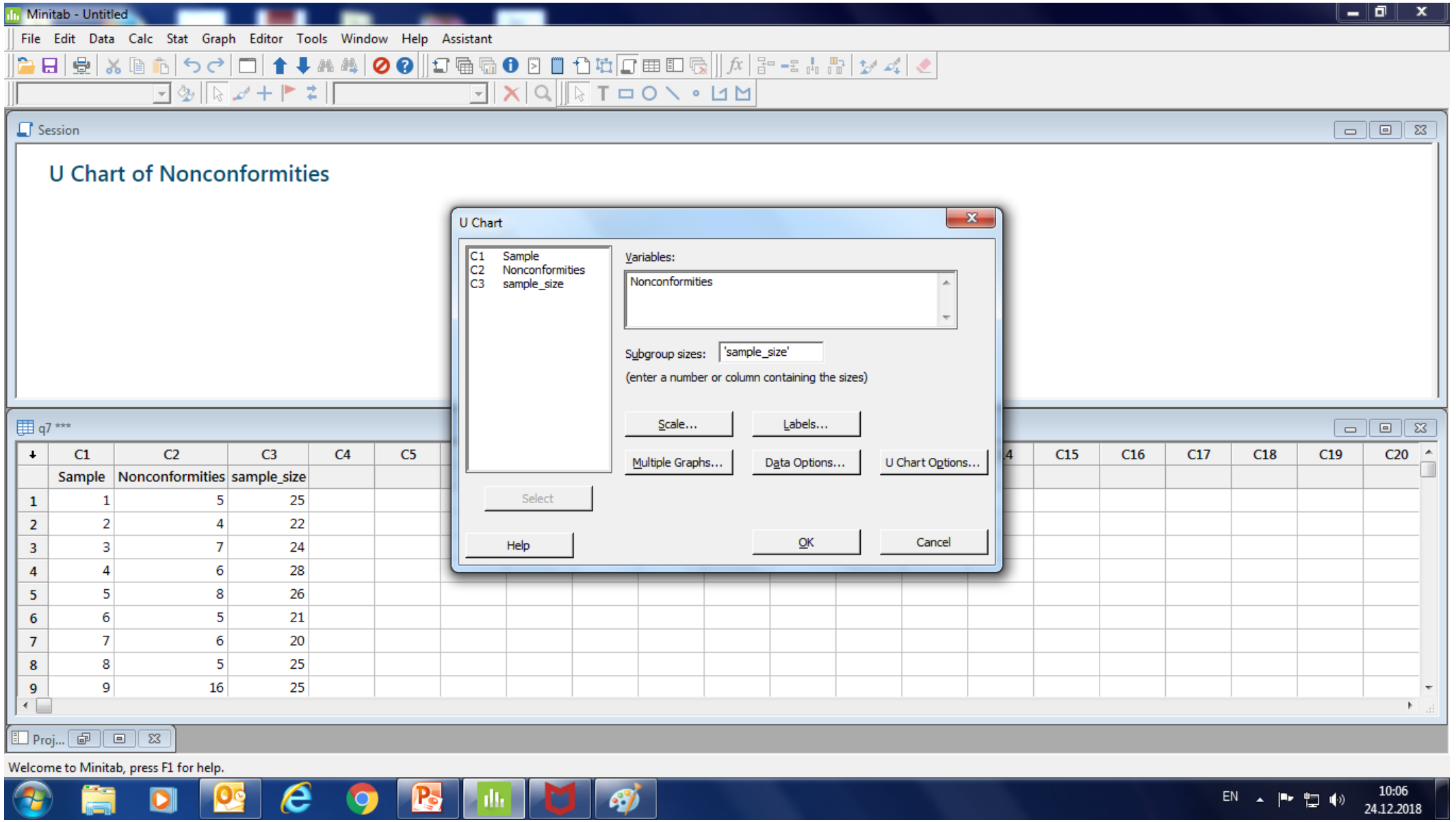

Minitab - Untitled - [C Chart of Number of Nonconformities]
File Edit Data Calc Stat Graph Editor Tools Window Help Assistant
C Chart of Number of Nonconformities
Sample Count
Sample
1
UCL=7,048
C̄=2,4
LCL=0
0 1 2 3 4 5 6 7 8 9
1 3 5 7 9 11 13 15 17 19
Current Worksheet: q6
EN
16:32
24.12.2018

Example of U Chart

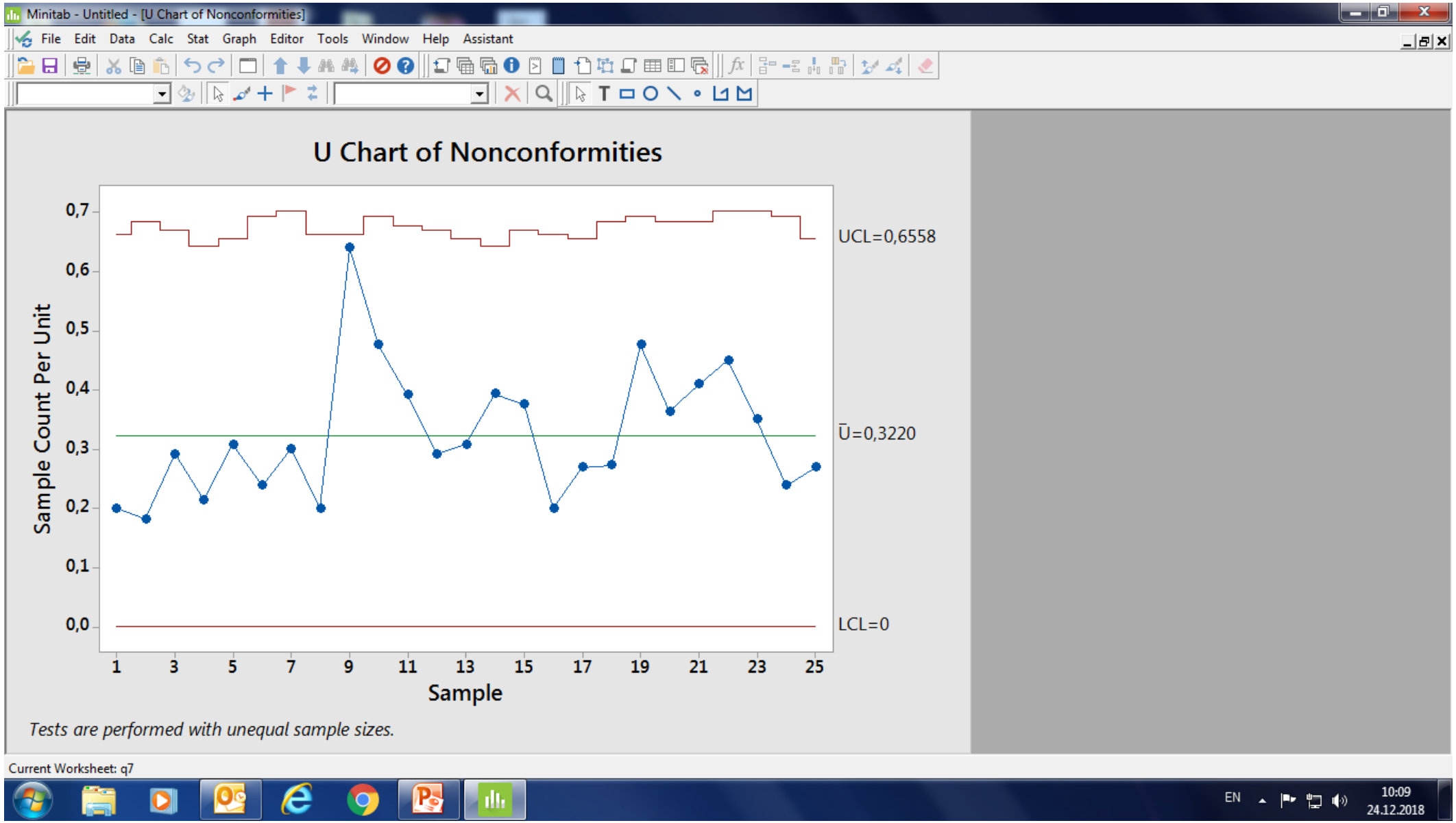
A manager for a transcription company wants to assess the quality of the transcription service. The manager randomly selects 25 sets of pages from consecutive orders and counts the number of typographical errors (defects). Each set has a different number of pages.

The manager creates a U chart to monitor the number of errors.

1. Open the sample data, IENG484-LAB3-4 from course webpage, transfer the q7 data to minitab .
2. Open the U Chart dialog box.
    - PC: STATISTICS > Control Charts > Attribute > U
    - Mac: Statistics > Attribute > U
3. In Number of defects per unit column, enter Nonconformities.
4. From the drop-down list, choose Subgroup sizes are in a column. In Subgroup sizes column, enter sample_size.
5. Click OK.



	C1	C2	C3	C4	C5	C15	C16	C17	C18	C19	C20
	Sample	Nonconformities	sample_size								
1	1	5	25								
2	2	4	22								
3	3	7	24								
4	4	6	28								
5	5	8	26								
6	6	5	21								
7	7	6	20								
8	8	5	25								
9	9	16	25								


Minitab - Untitled - [U Chart of Nonconformities]
File Edit Data Calc Stat Graph Editor Tools Window Help Assistant
U Chart of Nonconformities
Sample Count Per Unit
0,7
0,6
0,5
0,4
0,3
0,2
0,1
0,0
UCL=0,6558
Ū=0,3220
LCL=0
1 3 5 7 9 11 13 15 17 19 21 23 25
Sample
Tests are performed with unequal sample sizes.
Current Worksheet: q7
EN
10:09
24.12.2018

Acceptance sampling by attributes

Rectifying Inspection

All defective units found in the inspected sample are removed and replaced with Compliant product **AND** if the lot is rejected , 100% inspection is performed and all Defective nits are replaced.

AOQ

Average outgoing quality is the expected outgoing quality of a lot (of a given incoming quality) after rectifying inspection has been performed.

AOQL

Average outgoing quality limit is the worst case AOQ and is specified at the incoming quality that after rectifying inspection results in the maximum AOQ.

ATI

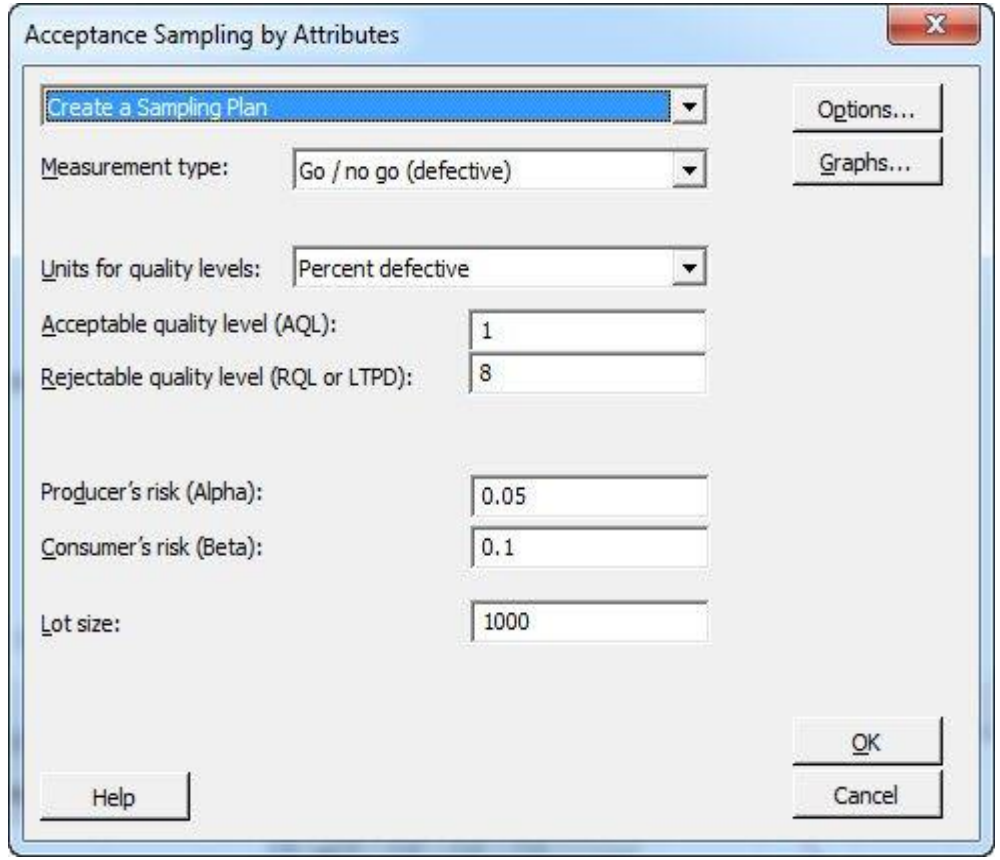
Average total inspection is the expected number of units inspected assuming rectifying inspection.

Creating Your Plan for Acceptance Sampling by Attributes

Now we can use Minitab to determine an appropriate sampling

1. Choose Stat > Quality Tools > Acceptance Sampling by Attributes.
2. Choose Create a sampling plan.
3. In Measurement type, choose Go / no go (defective).
4. In Units for quality levels, choose Percent defective.
5. In Acceptable quality level (AQL), enter 1. In Rejectable quality level (RQL or LTPD), enter 8.
6. In Producer's risk (Alpha), enter 0.05. In Consumer's risk (Beta), enter 0.1.
7. In Lot size, enter 1000.
8. Click OK.

Minitab produces the following output in the Session Window:




```
Generated Plan(s)

Sample Size          65
Acceptance Number     2

Accept lot if defective items in 65 sampled ≤ 2;  Otherwise reject.


  Percent  Probability  Probability
Defective    Accepting    Rejecting     AOQ     ATI
        1        0.972        0.028   0.909    90.8
        8        0.099        0.901   0.741   907.3

Average outgoing quality limit (AOQL) = 1.968 at 3.450 percent defective.
```

Lets do it with another example with
AQL =1.5
Alpha=0.05
Beta=0.10
Lot size =2500
RQL=7.5% and also at 11.5%
Use percent defective for units

Minitab - Untitled

File Edit Data Calc Stat Graph Editor Tools Window Help Assistant

Session

Method

Acceptable Quality Level (AQL)	1,5
Producer's Risk (α)	0,05
Rejectable Quality Level (RQL or LTPD)	7,5
Consumer's Risk (β)	0,1

Generated Plan(s)

Sample Size	88
Acceptance Number	3

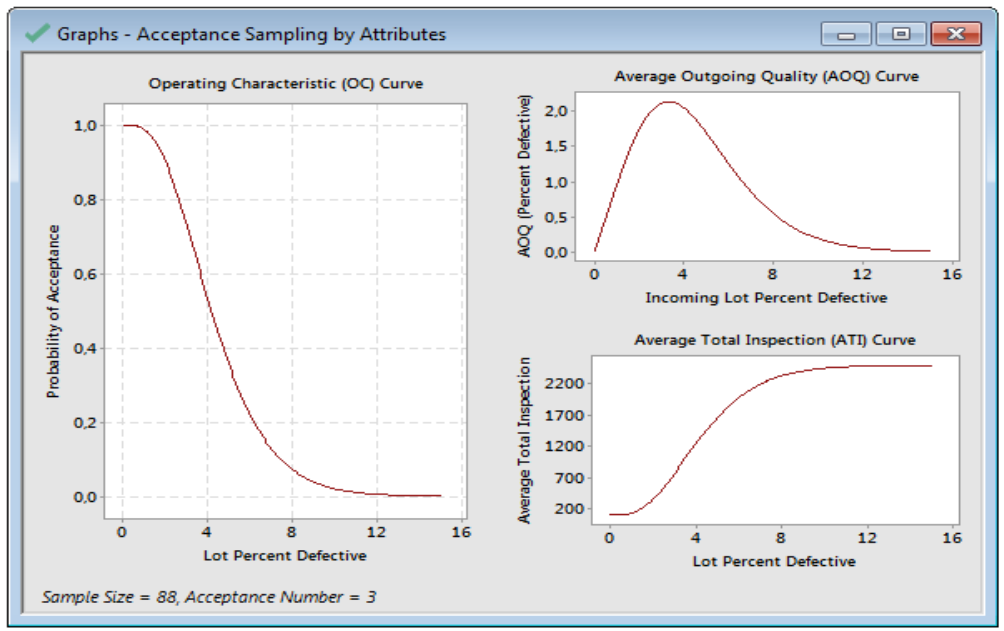
Accept lot if defective items in 88 sampled ≤ 3; Otherwise reject.

Percent Defective	Probability Accepting	Probability Rejecting	AOQ	ATI
1,5	0,956	0,044	1,384	193,7
7,5	0,096	0,904	0,696	2267,9

Average Outgoing Quality Limit(s) (AOQL)

AOQL	At Percent Defective
2,130	3,321

Graphs - Acceptance Sampling by Attributes



Proj...

Current Worksheet: Worksheet 1

EN 17:14 24.12.2018

Minitab - Untitled

File Edit Data Calc Stat Graph Editor Tools Window Help Assistant

Session

Method

Acceptable Quality Level (AQL)	1,5
Producer's Risk (α)	0,05
Rejectable Quality Level (RQL or LTPD)	11,5
Consumer's Risk (β)	0,1

Generated Plan(s)

Sample Size	45
Acceptance Number	2

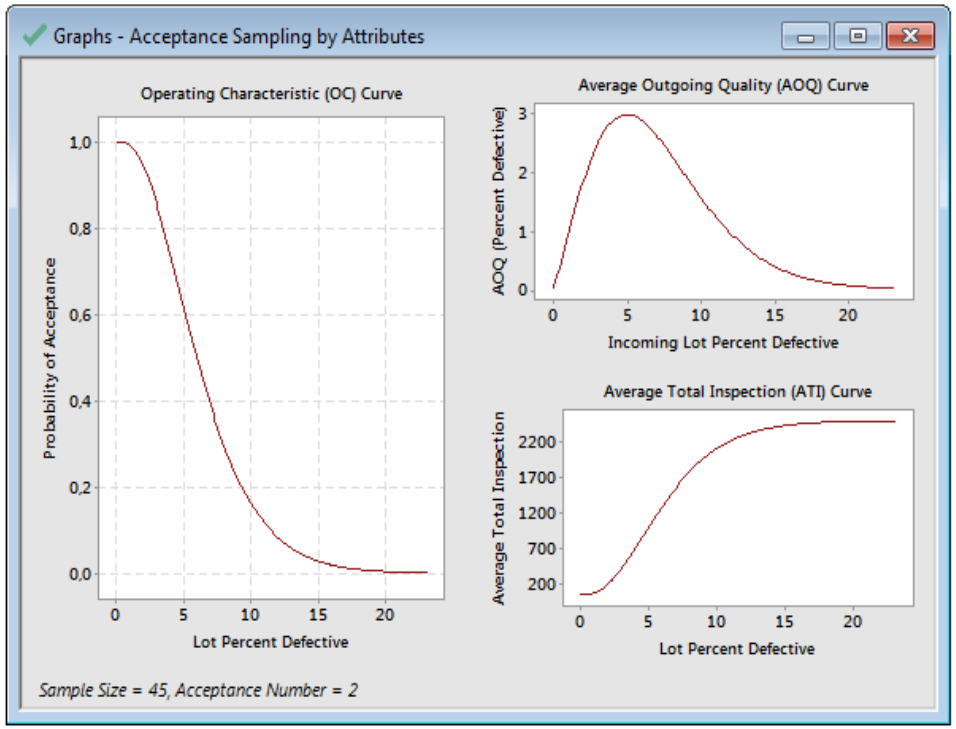
Accept lot if defective items in 45 sampled ≤ 2; Otherwise reject.

Percent Defective	Probability Accepting	Probability Rejecting	AOQ	ATI
1,5	0,970	0,030	1,429	118,7
11,5	0,097	0,903	1,090	2263,0

Average Outgoing Quality Limit(s) (AOQL)

AOQL	At Percent Defective
2,984	4,957

Graphs - Acceptance Sampling by Attributes



Proj...

Current Worksheet: Worksheet 1

EN 17:16 24.12.2018

THANKS FOR YOUR ATTENTION

- For further information :

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FATEMEH.ABBASI@cc.emu.edu.tr