

B.Sc. Operations Management Exam 20.12.2022

Started: Dec 20 at 10am

Quiz Instructions

This exam consists of 6 question sections. You have to answer all questions included in these 6 sections. You have 130 minutes (120 + 10 minutes) to complete the examination. The maximum of points that can be reached is 120.

You are allowed to use the collection of formulae and statistical tables, and a non-programmable pocket calculator. Regardless of whether the exam is taken on campus or online, all participants must print out the formula and table sheets themselves and have it released by the proctor before the exam. Notes on the printouts are not allowed. Communication with fellow students or other persons is not allowed. Specifically exchanging the way of solving the exam problems with others is seen as a violation of the examination guidelines as well as the Honour Code and will result in evaluating the exam as failed.

Please note that trailing zeros (that is, any zero that appears to the right of both the decimal point and every digit other than zero) are automatically removed in Canvas. For example, if you are requested to enter the number 111.80 with two decimals, Canvas will show 111.8. When grading your solution, we will automatically add trailing zeros as requested. Please note also that the way how decimal and thousand separators are shown in edit fields and in some of the question texts depends on your Canvas language setting (to be found in >account >settings). We recommend to change this setting to "English" to reduce potential confusion.

It is recommended to include units in the descriptions of your solution path, as it is easier to self-detect errors. However, if the question does not explicitly ask for including units, no points are deducted in case units are missing.

To start, click the "Take the Quiz" button. When finished, click the "Submit Quiz" button. The exam will save and submit automatically when the time expires.

We wish you success in the exam.

Question 1	1 pts
Section I	
<p>The InnoTec GmbH manufactures cable harnesses especially for agricultural machinery. The product 957E is manufactured on a production line with 9 workstations without buffers in between. Each cable harness passes through all workstations. One employee works at each workstation. A maximum daily delivery rate of 96 units 957E and a minimum rate of 64 units have been contractually agreed with the customer, that is, the agricultural machinery manufacturer Fendt.</p>	

The processing times at the 9 workplaces are summarized in the following table:

Work place	Processing time [min/unit]
1	7.8
2	7.8
3	7.8
4	9.4
5	9.4
6	8.4
7	9.1
8	7.2
9	7.5

InnoTec works 7.5 hours per shift and a maximum of 3 shifts per day.

How high is the implied utilization at the bottleneck if Fendt retrieves the minimum delivery quantity and InnoTec produces one shift per day? Please, enter your answer as a percentage with two decimals.

133.69

Question 2

5 pts

Please document your solution to the previous task.

Processing Time at Bottleneck = 9.4 min/unit

Bottleneck Capacity = $60/9.4 = 6.3830$ units/hr

As per given info:

Bottleneck Capacity = $6.3830 \text{ units/hr} * 7.5 \text{ hrs/shift} * 1 \text{ shift/day} = 47.8723$ units/day

Demand = 64 units/day

Implied Utilization at Bottleneck = $64/47.8723 = 133.6888888 = 133.69\%$

p



51 words



Question 3

4 pts

What cycle time (in minutes/unit) is required to produce the maximum delivery rate agreed with Fendt, if InnoTec is operating three shifts per day? Please document your solution.

Time available in a day = $60 \text{ min/hr} * 7.5 \text{ hr/shift} * 3 \text{ shifts/day} = 1350 \text{ min}$
Req. cycle time = $1350 \text{ min}/96 \text{ units} = 14.0625 \text{ min/unit}$

p



30 words



Question 4

4 pts

Assume that all work steps in the cable production can be subdivided as finely as needed. What is the cycle time of a perfectly balanced, capacity constrained production line? Please document your solution.

Labor content = $7.8 \times 3 + 9.4 \times 2 + 8.4 + 9.1 + 7.2 + 7.5 = 74.4$ min/unit

Cycle time of perfectly balanced process = $74.4/9 = 8.266666... = 8.2667$ min/unit

p



| 32 words |



Question 5

6 pts

InnoTec is considering changing its production line into a manufacturing cell in which each employee performs all nine steps of the cable harness production. Name and explain two disadvantages that the company will face as a result.

1. More equipment will be required (costs and waste): For nine cells, each cell requires the full set of equipment that is currently in one line. A lot of equipment replication is therefore necessary (so costs), and the utilization of each unit of equipment will be low as in a cell not all equipment will be used at the same time. This leads to waste.

2. Capacity issues: Switch-overs will be required between different steps and this will lead to idle time. Processing times will be longer as there is less learning. There is also more scope of error with one broad set of activities so defects will increase, overall capacity of good units will be compromised.

Question 6**1 pts****Section II**

The popular specialty of Ritter's bratwurst stand at the Frankfurt Christmas Market is the ½-meter Thuringian sausage. Produced according to an original Thuringian recipe in the family business in Pößneck, the sausage is delivered fresh at market opening time every single day. The boss of the bratwurst stand, Max Ritter, has to order the quantity of sausages in Pößneck two days ahead of delivery. To do this, he checks the current inventory level and the on-order quantity. An uninterrupted cold chain and storage at 2°C guarantees that the sausages will be kept fresh for at least three days after delivery. A storage facility near the Christmas Market is provided by coldstorage GmbH for 0.131 euros per sausage per day. The purchase price for one sausage is 1.49 euros.

Based on the normally distributed demand of the previous year, Max Ritter assumes an average demand of 831 sausages per day. He forecasts the coefficient of variation at 0.218. If all the sausages are sold out in one day, customers who then no longer can buy a sausage receive a voucher for a free sausage. As a result, Max Ritter misses out on a profit contribution of €2.43 per sausage.

What is the optimal in-stock probability of Ritter's bratwurst stand for the ½-meter sausage? Please, enter your answer as a percentage with two decimals!

Question 7**4 pts**

Please document your solution to the previous task.

p



12 words



Question 8

12 pts

If you did not solve the previous task, make a plausible assumption for the optimal in-stock probability for the following tasks that does not give you an unfair advantage.

What is the optimal order-up-to level for 1/2-meter Thuringian bratwurst? Please document your solution.

Searching for z^* such that $P(z < z^*) = 0.9488$

$P(z < 1.63) = 0.9484$ and $P(z < 1.64) = 0.9495$ so choose $z = 1.64$

$S = 831 \cdot 3 + 1.64 \cdot 0.218 \cdot 831 \cdot \sqrt{3} = 3007.59 = 3008$ sausages

p



33 words



Question 9

3 pts

What is the average on-order inventory? Please document your solution.

On-order inventory = daily demand*number of lead time periods = $831 \cdot 2 = 1662$

p



14 words



Question 10

1 pts

Section III

Happy dogs GmbH from Wehrheim manufactures various doghouses in two different factory halls. In factory hall A all woodworking machines are located. The assembly workplaces are in factory hall B.

For the assembly of the model "Taunus" four walls, two roof parts as well as a base plate are needed. These parts are all manufactured on the same modern, computer-controlled woodworking machine in hall A. Cleaning and setting up the machine to produce a wooden part takes 10 minutes, regardless of the type of part. The processing times per part are on average as follows:

Base plate	40 s
Wall	11 s
Roof part	25 s

Production planning has set the batch size for the "Taunus" model at 10 doghouses. Completed parts are continuously transported to assembly. The assembly rate for the Taunus model is 120 houses per 8-h working day.

Determine the length of a production cycle in minutes. Enter your result with two decimals.

52.33

Question 11

4 pts

Explain what is meant by a production cycle and document your solution to the previous task here.

A production cycle is the shortest repeatable production pattern in the overall production schedule. It includes the production (of different varieties) as well as setups.

1 component set consists of 4 walls, 2 roofs and 1 base plate.

PT of 1 component set = $4 \cdot 11 + 2 \cdot 25 + 40 = 134\text{s}$

Length of 1 production cycle = Total set up time + batch size * processing time per component set

= $3 \cdot 10\text{min} + 10 \cdot 134/60 \text{ min} = 52.333... \text{ min}$

Even though the calculation can be done this way, the actual production cycle produces 40 walls together, 20 roofs together and 10 base plates together. A component set does not stay together during the production

p



119 words



Question 12

5 pts

What is the capacity of parts production for the model “Taunus” per hour? Please document your solution.

Capacity = $(10/52.33) \cdot 60 = 11.4650$ component sets/hour

This means 45.86 walls, 22.93 roofs and 11.47 roofs are produced per hour.

p



22 words



Question 13

3 pts

If you have not solved the previous questions, please make a plausible assumption for the capacity that does not give you an unfair advantage.

Which production step is the bottleneck? Please document your solution.

Capacity of assembling = $120 \text{ units} / 8 \text{ hours} = 15 \text{ units/hr} > 11.4650 \text{ units/hr}$

Therefore, the woodworking/manufacturing of parts is the bottleneck.

p



25 words



Question 14

5 pts

What batch size do you recommend to minimize the inventory of parts between woodworking and assembly? Please document your solution.

Target capacity is the capacity of the assembly stage, i.e. 15 units/hr

Recommended batch size = $15 \cdot 0.5 / (1 - 15 \cdot 134 / 3600) = 16.9811 = 17$
component sets

p



25 words



Question 15

2 pts

Because another woodworking machine has a breakdown, not only the production cycle for the model "Taunus" but also that for the model "Westerwald" must be run on this woodworking machine. Which of the following statements is correct?

A: The production cycle for the type "Taunus" is significantly shortened, so that the average stock level is significantly reduced.

B: The batch size to produce the type "Taunus" parts increases significantly resulting in a sharp rise in the maximum inventory level.

☒ B

☐ A

Question 16

4 pts

Section IV

At the lake "Zwischenahner Meer", Onno Oncken, owner of a boat rental company, rents out electric boats. On average, 10 customers per hour arrive at the boat rental to rent a boat, which they then return after an average of half an hour (both the interarrival time and the rental duration can be assumed to be exponentially distributed). Onno Oncken owns 6 boats that are available for rental. Each electric boat is rented by exactly one tourist. Since the shore at the lake "Zwischenahner Meer" is beautiful and invites for a walk, tourists prefer this alternative instead of waiting for an electric boat.

What is the average number of boats Onno Oncken has available for rent to tourists at the boat rental? Please document your solution.

$$a = 6, p = 30, m = 6$$

$$\text{Utilization} = p/(am) = 30/(6*6) = 5/6$$

$$\text{Number of boats available} = 6*(1-5/6) = 1$$

p



27 words



Question 17

5 pts

Calculate the probability that there will be no electric boat available for a tourist arriving at the boat rental. Please document your solution.

$$r = 30/6 = 5$$

From Erlang Loss Table, $P_6(5) = 0.1918$

Therefore, the probability that no boat is available to customer is 19.18%

p



25 words



Question 18

3 pts

If you did not solve the previous task, make a plausible assumption for the probability that no electric boat is available that does not give you an unfair advantage.

What is the hourly rate of tourists having to take a walk around the “Zwischenahner Meer”? Please document your solution.

Rate of lost demand = probability a customer is lost * rate of incoming customers

= $0.1918 \cdot 10$ customers/hr = 1.918 customers/hr

On average, 1.918 customers have to take a walk around the Meer an hour.

p



36 words



Question 19

4 pts

How many electric boats would Onno Oncken have to provide in order to achieve a 95% probability of availability for his customers if 10 tourists continue to come per hour? Please document your solution.

Searching for m such that $P_m(5) \leq 0.05$

$P_8(5) = 0.07$ and $P_9(5) = 0.0375$ so choose 9.

Onno Oncken will have to provide 9 boats in total.

p



31 words



Question 20

4 pts

Onno Oncken provides a 3D boat simulator that prevents a customer from going straight for a walk when no boat is available. Instead, the customer waits for the next free boat and spends the time until it arrives in the simulator. Argue how this measure changes expected sales.

This would depend on the queuing times and still how willing an individual is to wait but if we assume that a customer is always willing to wait for as long as may be necessary, there are no lost sales and the expected sales increase such that they become equal to incoming demand.

p



53 words



Question 21

1 pts

Section V

The Munich sports store "Sport Schick" has specialized in the sale of skis. For the upcoming ski season, the brand new ski "Fellköll RACETIGER SL" will be launched. It is planned by the sports store to offer the ski for sale for € 699,00. "Sport Schick" orders the "Racetiger SL" directly from the ski manufacturer "Fellköll" for a purchase price of € 499.00, although repeat orders during the season are not possible due to the long delivery times on the part of "Fellköll". After the ski season, it is expected that all leftover pairs of the "Racetiger SL" can be sold at a discount price of € 399.00 each. It is known from previous winter seasons that demand was normally distributed and an average of 224 pairs of skis of the old models of the "Racetiger" were sold with a standard deviation of 44 pairs.

"Sport Schick" plans to order 330 pairs of skis of the "Racetiger SL". Calculate what revenue can still be expected from the sale of the remaining stock of the "Racetiger SL" after the end of the ski season. Please enter your solution with two decimals.

42,355.61

Question 22

5 pts

Please document your solution to the previous task.

$$D \sim N(224, 44^2)$$

$$z = (330 - 224) / 44 = 2.40909... = 2.41$$

$$\text{Expected Leftover inventory} = 44 * I(2.41) = 44 * 2.4126 = 106.1544$$

$$\begin{aligned} \text{Expected Revenue from Leftover Inventory Sale} &= 399 * 106.1544 = \\ 42,355.6056 \text{ EUR} &= 42,355.61 \text{ EUR} \end{aligned}$$

Question 23

3 pts

Calculate the probability that "Sport Schick" cannot sell the planned order quantity of the "Racetiger SL" during the winter season. Please document your solution.

Will not sell if demand is too low, so calculate $P(D < 330)$.

We already calculated $z=2.41$ in previous question.

$P(\text{quantity does not sell out}) = P(z < 2.41) = 0.9920 = 99.2\%$

p



32 words



Question 24

6 pts

Calculate the optimal order quantity for the "Racetiger SL". Please document your solution.

$$C_u = 699 - 499 = 200,$$

$$C_o = 499 - 399 = 100$$

$$\text{Critical ratio} = \text{Target in-stock probability} = 200 / (200 + 100) = 2/3 = 0.666667$$

Looking for z^* such that $P(z < z^*) = 0.6667$

We have $P(z < 0.43) = 0.6664$ and $P(z < 0.44) = 0.6700$ so choose 0.44

$Q^* = 224 + 44 \cdot 0.44 = 243.36 = \text{round up to } 244$

p



56 words



Question 25

5 pts

What are the mismatch costs when ordering the planned quantity (note: not the optimal quantity from the previous question)? Please document your solution.

$Q = 300$ gives leftover inventory 106.1544 (calculated in Q22)

Expected Sales = $300 - 106.1544 = 193.8456$

Expected Profit = $200 \cdot 193.8456 - 100 \cdot 106.1544 = 28,153.68$

Mismatch Costs = Max profit - expected profit = $224 \cdot 200 - 28,153.68 = 16,646.32$

p



35 words



Question 26**3 pts****Section VI**

FerrumArtis AG produces seamless steel tubes using the cross-roll piercing process. The standard tube "Ferrum standard 3200", which is in high demand from the chemical industry, is cut to an average length of 320 cm. The outside diameter is 5 cm. The upper (lower) specification limit for the length is 322.37 cm (318.95 cm).

Deviations from the mean value are normally distributed. The standard deviation of the length is 0.811 cm.

What is the process capability index for the length cutting process? Please enter your solution with four decimals.

Question 27**3 pts**

Comment on the capability index calculated in the previous task. (If you did not solve the previous task, assume a process capability index of 0.7893).

The capability index is low and not sufficient to meet quality standards. The standard deviation is too high considering the specification limits, and needs to be reduced. There is too much variability in the process right now.

p



37 words



Question 28

4 pts

Calculate the probability that a produced tube is too long. Please document your solution.

$$L \sim N(320, 0.811^2)$$

$$\begin{aligned} P(\text{too long}) &= P(L > 322.37) = P(z > 2.37/0.811) = P(z > 2.9223) = P(z > 2.92) \\ &= 1 - P(z \leq 2.92) = 1 - 0.9982 = 0.0018 = 0.18\% \end{aligned}$$

p



29 words

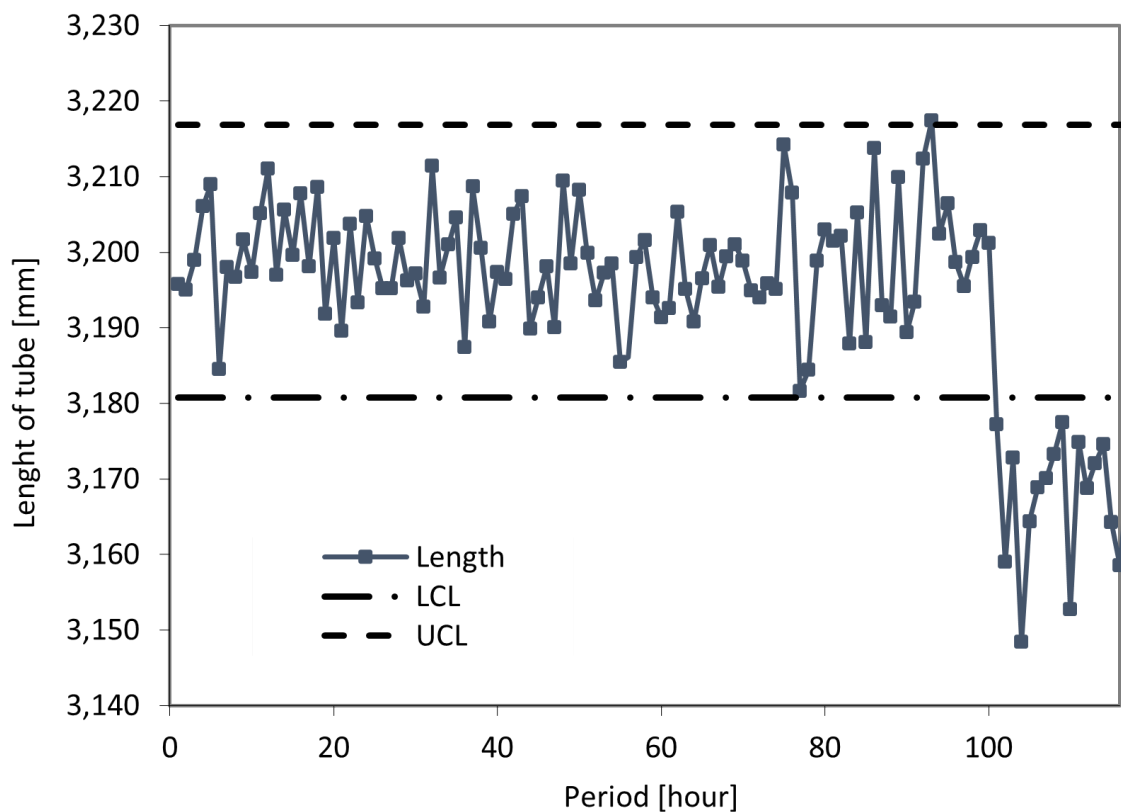


Question 29

6 pts

Every hour, the length of a pipe that has just been produced is precisely measured and entered into a quality control chart. FerrumArtis' Quality Engineer Robert Ton receives the following chart at the beginning of his working day. (If you encounter any problems with the chart, please use the [PDF version.](#))

(<https://frankfurtschool.instructure.com/courses/9226/files/556568?wrap=1>)



As a user of the concept of statistical process control, what will he recognize at first glance and what further steps will he undertake? Relate your answer as specifically as possible to the production of the "Ferrum standard 3200".

A serious assignable cause error occurred at the 100th hour which caused the length to drop well below the LCL as well as the LSL.

All production since then has been defective so as per this information, the error has not been rectified.

It is essential to stop the process and fix the error before proceeding further. One possible solution could be recalibrating the machine equipment, or conducting other maintenance and repairs. Production should resume only after the defect is eliminated and new pieces are inspected to be within control.

The controller can further use the Ishikawa model to conduct a root-cause analysis as to why the error occurred in the first place and then take

Question 30

4 pts

Why is the upper control limit below the upper specification limit? Comment on the reverse situation (i.e. the upper control limit is above the upper specification limit).

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Specification limits are based on requirements and are set more theoretically. Control limits however are statistical measures about the actual output quality of the process. UCL below USL means that the qualities that are above the mean, are still closer to the mean than they strictly need to be. This is a good indicator and tells us that the process is in control.

However, if the UCL were to be above USL, this means that the quality shows more deviation above the mean than is acceptable. This means that the process is not in control, and the variability needs to be reduced urgently.

p



103 words



Quiz saved at 11:59am

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