Question 1

2 / 2 pts

A popular bakery in Frankfurt's Nordend opens at 7:00 in the morning till its well-deserved lunch break at 12:00. A nosy neighbor counts the people entering the bakery. The last customer entering gets number 101! What is the average flow rate of customers leaving the bakery per minute? Please enter your solution with 4 decimals.

0.3366

0.3367

For example, Flow Time = 5 hours and entering customers (= leaving customers!) in 5 hours = 93.

Thus, average flow rate = 93 customers / 5 hours = 18,6 customers / hour = 18,6 customers / 60 minutes = 0,31 customers / minute.

Question 2 2 / 2 pts

Question 2

2 / 2 pts

On another day, 13 customers wait in front of the bakery at the time it opens. The rate at which customers get served is 50 persons per hour. How many minutes does it take to serve the last customer in the queue? Please enter your solution with two decimals.

15.6

15.6

Solution:
The formula to calculate the time to serve the Qth person in the queue is needed:

T = Q/Capacity

For example, if 10 customers wait and the rate at which customers get served, what (which?) is equivalent to the capacity, is 50 persons per hour.

T = 10 customers / 50 customers/hour = 0.2 hours = 12 minutes.

Question 3

2 / 2 pts

To avoid rework is to do it right the first time .

Answer 1:

do it right the first time

Yes, the correct answer is "...do it right the first time".

Question 4

1 / 1 pts

C&A is making steel rods with an average diameter of 1 mm. The process has a standard deviation of 0.2 mm. The upper and lower specification limits are 1.2 mm and 0.8 mm respectively. What is C&A's process capability index? Explain your solution path below.

- 0.16
- 0.33

Correct answer.

- 0.84
- 0.68

Question 6

0 / 1 pts

C&A holds on average $20,304 in inventory throughout the year. Trade accounts receivable amounts to $17,814. Its yearly cost of goods sold is $246,483, and yearly sales are $391,113. Calculate C&A's inventory turns per month? Please enter your solution with two digits and explain your solution path below.

1.01

Correct solution:

The montly inventory turns are calculated as (COGS/12)/Inventory.

It is important to convert COGS form $ per year into $ per month.

Question 8

1 / 1 pts

You are considering four hotels that differ from each other with respect to their price and customer reviews:

Hotel	Price	Reviews (1 = worst . . . 5 = best)
H1	$100	3
H2	$250	5
H3	$200	4
H4	$150	2

Which of these hotels is NOT on the efficient frontier? Please explain your answer below.

- H2
- H4

Explanation: At least one competitor is better on both factors than H4. H4 is

Question 9

2 / 2 pts

Please explain your solution to the question above.

Your answer:

H2 has the best rating an the highest price --> its in the effeciency frontier

H1 hast the lowest price and the second highest rationg --> is on frontier

H3 compared to H4 has is more expencieve but has also a higher rating, compared to H1 it has a higher rating with a slight price increase but H4 is more expensive than H3 but with a lower rating --> therefore is not on the frontier cause is the less efficient one

Question 10

2 / 2 pts

A worker moving inventory from one machine to another is considered non-value-added work.

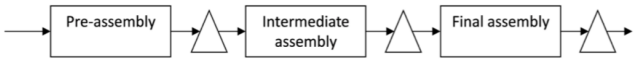
- True

Correct.

Explanation: Moving inventory is not value-adding.

- False

The assembly process of the innovative product "meparc" is depicted in the process flow diagram below:



Each of the three assembly stages is staffed with one full-time equivalent worker working eight hours per day.

Assembly consists of activities (a) to (n) that need to be conducted in the sequence shown in the table below and that are assigned to one of the three assembly stages.

Activity	Time per activity [FTE·min/unit]	Activity assigned to pre-assembly	Activity assigned to intermediate assembly	Activity assigned to final assembly
(a)	11	yes		
(b)	10	yes		
(c)	1	yes		
(d)	6	yes		
(e)	2	yes		
(f)	9		yes	
(g)	5		yes	
(h)	4		yes	
(i)	1		yes	
(j)	1		yes	
(k)	6			yes
(l)	4			yes
(m)	4			yes
(n)	2			yes

For instance, activity (a) is assigned to pre-assembly, while activity (k) is assigned to final assembly. Workers are cross trained so that they can perform all required activities and in the same time per activity as indicated above.

First, processing times need to be calculated:

Processing time pre-assembly: 11 + 10 + 1+ 6+ 2= 30 [FTE·min/unit]

Processing time intermediate assembly: 9+ 5+ 4+ 1+ 1 =20 **[FTE·min/unit]**

Processing time final assembly: 6+ 4+ 4+ 2= 16 **[FTE·min/unit]**

Capacity per stage is as follows:

Assembly station	#FTE[FTE]	Processing Time **[FTE·min/unit]**	Capacity [unit/min]	Capacity [unit/h]
Pre assembly	1	30.0	0.0333	2
Intermediate assembly	1	20.0	0.0500	3
Final assembly	1	16.0	0.0625	3.75
	3.0	66.0		

Pre-assembly has the lowest capacity. Therefore, this stage is the bottleneck.

Question 12

0 / 1 pts

Calculate the total idle time of all workers in hours per day (each day equals 8 hours). Enter your solution with one decimal and explain your solution path below.

0.4

6.4 (with margin: 0.01)

Cycle time is the processing time at the bottleneck stage.

Cycle time = 30min.

Idle time per unit= Cycle time- Labor content

Station	Cycle Time [min/unit]	#FTE [FTE]	Labor content [FTE·min/unit]	Idle Time [min/unit]
Pre-assembly	30.0000	1	30.0	0.0000
Intermediate assembly	30.0000	1	20.0	10.0000
Final Assembly	30.0000	1	16.0	14.0000
		3	66.0	24.0000

Flow rate = 1/Cycle time = 1/ (30 min/unit) * 60 min/h * 8h/day = 16 units/day

Total idle time: 16 units/day + 24 FTE·min/unit = 384 FTE·min/day = 6.4 FTE·h/day

Alternate approach:

The Flow rate is currently 2 units/hour. Hence, assembly can produce 16 units per day. The idle time for int.-assembly is 8-(8*20/30) =2.67 hours and for final assembly 8-(8*16/30) =3.73 hours. Since pre-assembly is the bottleneck the idle time equals zero. Total idle time per day is 2.67 + 3.73 = 6.4 hours.

Question 13

3 / 4 pts

Explain how you calculated the total idle time of all workers in the question above.

Your answer:

idle time formula = cycle time * no of worker - labor content

no of worker = 3

cycle time = 1/ flow rate --> flow rate in this case bottleneck

1/ 1/30/min = 30 min

labor content = all processing times added up = 66 min

idle time = (30 min * 3) - 66 min = 24 min --> 24/60 = 0.4 Hours

Question 14

0 / 2 pts

What is the cycle time in minutes per unit of a perfectly balanced production system, whereby perfectly indicated a utilization of 100% at all assembly stages?

22 (with margin: 0)

In a balanced system, cycle time is equal to the processing time at all stations. Therefore, cycle time can be calculated as:

Total labor content / 3 workstations

66 min/unit / 3 = 22 min/unit

Question 15

0 / 3 pts

Assign activities to assembly stages so that the assembly process is perfectly balanced, and all constraints are satisfied.

Activity	Time per activity [FTE· min/unit]	Pre-assembly	Intermediate assembly	Final Assembly
(a)	11	1	0	0
(b)	10	1	0	0
(c)	1	1	0	0
(d)	6	0	1	0
(e)	2	0	1	0
(f)	9	0	1	0
(g)	5	0	1	0
(h)	4	0	0	1
(i)	1	0	0	1
(j)	1	0	0	1
(k)	6	0	0	1

Question 16 0 / 3 pts

What is the flow rate after line balancing in units per day (remember: one day equals 8 hours)? Please enter your solution with 2 decimals.

21.82 (with margin: 0)

Flow rate = 1/cycle time = 1/(22min/unit) = 1/22 unit/min

1/22 * 60 * 8 = 21.82 units/day

Question 17 0 / 1 pts

What is the idle time in minutes per unit in a perfectly balanced assembly system?

0 (with margin: 0)

0 min/unit

Section III

Frankfurt School's facility manager Heribert Toll needs to order toilet paper. He considers various suppliers and demand scenarios. Toll orders at the first day of each month and receives shipment at that same day. On average, the FS campus is open 26 days a month.

Question 18

1 / 2 pts

In this first scenario, demand is 54 toilet paper rolls per day. Supplier A charges 0.9 € per roll and 49 € per order (incl. transportation cost). FS annual inventory holding cost percentage is set to 24%. What are annual costs for purchasing? Please enter your solution with two decimals.

17,690.4

15,163.2

annual costs for purchasing = demand per day * 26 days/month * 12 month/year * price for one roll.

For example, demand = 70 rolls per day and the supplier charges 1 € per roll:

annual costs for purchasing = 70 rolls/day * 26 days/month * 12 month/year * 1 €/roll = 21840 €/year.

Question 19

0 / 2 pts

In this second scenario, demand is 54 toilet paper rolls per day. Supplier B charges 0.9 € per roll and 57 € per order (incl. transportation cost). FS annual inventory holding cost percentage is set to 21%. What are annual costs for ordering and transportation?

684

Solution:

Ordering costs = 12 orders per year * ordering costs.

For example, if ordering costs are 50 €/order:

12/year*50 EUR=600 EUR/year

Question 20

0 / 1 pts

In this third scenario, demand is 58 toilet paper rolls per day. Supplier C charges 1.03 € per roll and 41 € per order (incl. transportation cost). FS annual inventory holding cost percentage is set to 22%. Determine annual inventory holding costs. Please enter your solution with two decimals and explain your solution path below.

170.86

The correct answer is calculated as follows:

Mr. Tolls orders once a month. Inventory level on average therefore is demand per day * 26 days per month divided by 2.

Costs are determined by multiplying average inventory with the holding costs (holding cost percentage * purchase price per unit).

For example, if demand = 50 rolls per day, 20% annual inventory holding cost percentage and a purchase price of 1 Euro per roll:

Annual inventory holding costs = 26*50/2*20%/year*1EUR=130 EUR/year

Question 21

1 / 2 pts

Explain here how you calculated annual inventory holding costs in the third scenario.

Question 22

0 / 1 pts

Calculate the optimum order quantity for a fourth scenario with a demand of 79 toilet paper rolls per day, ordering and transportation costs of 74 € per order and a purchase price of 0.99 € per roll from supplier D. The annual inventory holding cost per unit is 0.195€.

Please enter your solution as a whole number and explain your solution path below.

4,672

4,325

The correct solution is determined using the EOQ formula.

Question 23

3 / 3 pts

Please explain here how you calculated the optimal order quantity in the fourth scenario.

Question 24

0 / 1 pts

Mr. Toll considers a fifth scenario with a demand of 50 toilet paper rolls per day, a purchase price of 1.00 € per roll, ordering and transportation costs of 100 €, and annual inventory holding costs of 0.195 € per unit. He correctly calculates an optimal order quantity of 4000 rolls and starts negotiations with supplier E. Finally, Mr. Toll receives an offer to get a 1% price discount, if he orders 7000, 10000 or 13000 units per time. What is the optimum order quantity in this situation? Enter your solution as whole number and explain your solution path below.

7,000 (with margin: 0)

The optimal order quantity is 7000 toilet paper rolls.

Question 25

1 / 8 pts

Please explain here how you calculated the optimal order quantity in the fifth scenario.

First, the new purchase price and annual holding cost per unit are calculated:

Purchase price with discount	0.99	€/unit
Holding cost percentage	19.50%	1/(unit*year)
Holding cost per unit	0.1931	€/(unit*year)

The EOQ taking the discount into account is: 4020.15 unit.

It does not make sense to order 10000 or 13000 rolls, because the order quantity of 7000 guarantees that the discount is closer to the optimal EOQ.

Total annual costs are calculated:

First, Q = 4000:

15600.00 €/year purchase cost for 4000 rolls.

390.00 €/year order and transportation cost for 4000 rolls

390.00 €/year holding cost for 4000 rolls

16380.00 €/year total costs for 4000 rolls.

Second, Q = 7000

15444.00 €/year purchase cost for 7000 rolls.

222.86 €/year order and transportation cost for 7000 rolls

675.68 €/year holding cost for 7000 rolls

16342.53 €/year total costs for 7000 rolls.

Section IV

The "BBC experience" company offers innovative grills for the next spring and summer season (starting 1st April and ending 31st August). Due to the high-quality standards, the production of a grill takes rather long so that production on short term is impossible. The demand of grills for the next season is uncertain. Hence, the determination of the optimal number of grills to be produced is a critical issue for "BBC experience".

Question 26

0 / 3 pts

The forecasting team comes up with a forecast of 1260 units per season for model AJT5. The team's forecast quality is characterized by an average A/F ratio of 0.85 and standard deviation of 0.1724. Determine a distribution that captures such variability in demand.

The correct answer:

A distribution is needed to capture variability. As no information about the distribution of the forecast error is provided, a normal distribution is the natural choice. This is supported by the rather high numbers (>20) predicted for the next season, which is a strong indication against a Poisson distribution.

With the numbers provided above, the demand forecast is a normal distribution with:

Mean = $1260 \cdot 0.85 = 1071$

Std dev = $0.1724 \cdot 1260 = 217.224$

Question 27

3 / 3 pts

For the grill BTJ6 demand is forecasted as normally distributed with an average of 1160 units per season and a standard deviation of 200 units/season. What is the probability that all orders are filled if "BBC experience" produces 1000 grills? Please enter your solution as percentage with two decimals.

21.19

21.19 (with margin: 0)

The correct answer:

$z = (x - \mu) / \text{sigma} = (1000 - 1160) / 200 = -0,8.$

$F(z = -0,8) = 21,19\ \%.$

Question 28

0 / 3 pts

Suppose "BBC experience" wants to guarantee at least a probability of 90% that demand for BTJ6 can be fulfilled. How many grills do they have to produce?

1,418 (with margin: 0)

The correct answer:

The objective is to reach a probability of 90%. z(0,90) = 1,29.
Q = μ + z · sigma = 1160 + 1,29 · 200 = 1418.

Question 29

0 / 3 pts

"BBC experience" can produce the grill model CJT7 at a unit cost of 115€. The selling price is 179€ during the season. From 1st September on the price is reduced to 76€ per grill so that eventually all remaining grills are sold. What is the critical ratio? Please enter your solution with 4 decimals.

0.6214

For example, in the scenario:

"BBC experience" can produce the grill model CJT7 at a unit cost of 120€. The selling price is 180€ during the season. From 1st September on the price is reduced to 80€ per grill."

The correct answer is:

CU = 180 - 120 = 60; CO = 120 - 80 = 40

Critical Ratio = CU / (CU + CO) = 60 / (60 + 40) = 0.6

Question 30

0 / 1 pts

Demand for the DJT8 is forecasted as normally distributed with an average of 995 units/season and a standard deviation of 87 units/season. Selling price is set to 155 €/unit, purchase price is 90€/unit, and salvage value is 65 €/unit.

What are the mismatch costs that "BBC experience" expects for DJT8 per season when ordering the optimal quantity? Round this optimal order quantity up to a whole number. Please enter your solution for the mismatch costs with two decimals and explain your solution below.

2,581.6 (with margin: 0.5)

Question 31

2 / 7 pts

Please explain here how you determined DJT8's mismatch costs.

Solution:

DJT8

Overage Costs Co: 90 - 65 = 25.00 €/unit (0.5 P)
Underage Costs Cu: 155 - 90 = 65.00 €/unit (0.5 P)

CR =0.7222

z = 0.59

Q* = 1046.33 units/season

Q* Rounded up = 1047 units/season (2 P)

Approach A:

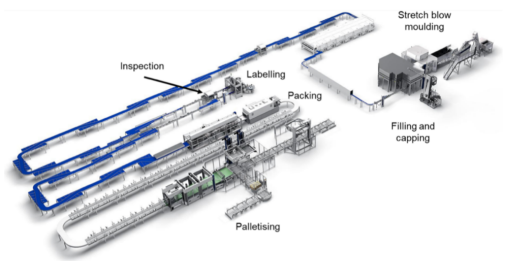
Expected inventory from table:
I(0.59) =0.7614
Expected inventory = 0.7614 * 87 = 66.24 units/season

ES = 1047 - 76.24 = 980.76 €/season
EP = ES * p + EI * sv – Q * c (2 P)
Expected profit = 62,093.40 €/season
MP = Cu * μ (1 P)
Maximum profit =64,675.00 €/season
MMC = MP – EP (1 P)
Mismatch costs = 2,581.60 = €/season

Approach B
ELS = μ - ES = 995 - 980.76 = 14.24 units/season
MMC = Cu * ELS + Co * EI
= 65.00 €/unit * 14.24 units/season + 25.00 €/unit * 66.24 units/season = 2,581.60 €/season

Section V

Krones is a renown manufacturer of filling and packaging lines as shown below.



Source: https://www.krones.com/en/products/complete-solutions/filling-and-packaging-lines.php

Question 32

0 / 1 pts

Better Beverages AG uses one such line to fill both pure German "Pils" and "Radler". It takes 38 minutes to switch the line from the filling "Pils" to filling "Radler" or vice versa. Producing an output of 19,120 bottles of beer (no matter "Pils" or "Radler") takes one hour. One single bottle takes 5.3 minutes to move through the whole line from its beginning to its end. In the morning, the line is empty and needs to be set up for beer. How long does it take to produce an output of 1000 bottles? Please enter

from its beginning to its end. In the morning, the line is empty and needs to be set up for beer. How long does it take to produce an output of 1000 bottles? Please enter your solution in minutes with 3 decimals and explain your solution below.

46.435

The correct answer is:

For example:

Flow rate when producing = 20,000 bottles/hour

Cycle time = 1/20,000 hour/bottle = 0.00005 hour/bottle = 0.003 min/bottle = 0.18 s/bottle

Time to produce the first bottle: 5 min

Time to produce 999 bottles = 999 * 0.003 = 2.997 min

Time to setup = 30 min

Time to produce 1000 bottles = (30 + 5 + 2.997) min = 37.997 min

Question 33

1 / 3 pts

Explain how you calculated your answer to the previous question?

Question 34

0 / 6 pts

Better Juices AG fills apple juice and orange juice using a Krones line with an output rate of 20000 bottles per hour when producing. Setup time is 30 minutes, no matter whether we change from apple juice to orange juice or vice versa. Demand is as follows: 10000 bottles of apple juice per hour and 5000 bottles of orange juice per hour. How many bottles of orange and apple juice are included in a batch to match demand? Explain your solution path.

Correct answer is:

Define one batch as a set of “Apple” and “Orange”.

RBS = (Tar. Capacity · Total Setup Time) / (1 - Tar. Capacity · Processing Time)

Target capacity is 15000 bottles per hour (10000 bottles + 5000 bottles)= 15000

15000 [bottles/hour]/60 [minute/hour] = 250 [bottles/minute]

Total Setup Time = 2 · 30 = 60 min

Processing Time = 0.003 minutes / bottle

RBS = (250 bottles/min ·2·30 min) / (1 - 250 bottles/min · 0.003 min/bottle)= 15000 bottles / 0.25 = 60000 bottles

Split in proportion of demand:

Apple: 10000/15000 · 60000 = 40000

Orange: 5000/15000 · 60000 = 20000

Question 35

1 / 4 pts

What batch size would allow Better Juices AG achieving a target capacity of 6 bottles per second? Explain.

Correct answer is:

The maximum capacity that can be achieved is given by 1/processing time.

Processing time is 1h/20000bottles*3600s/h = 0.18 s/bottle

Maximum capacity:

= 1/0.18 = 5.5556 bottles/s

Therefore, it is not possible to find a batch size that results in a capacity larger than 1/processing time.

Question 36

Better Veggie Juice GmbH is another user of a Krones line that fills a bottle in 0.24 seconds. Better Veggie Juice produces three different types of vegetable juices on this line. The company uses a batch size of 109,429 bottles and needs 33 minutes to change over (again, sequence does not matter as in the question above). Determine the capacity of the line in bottles per hour? Enter your solution as whole number.

12,233

Capacity = Batch size / (Total Setup Time + Processing Time · Batch Size)

For example:

Processing time = 0.2 s/bottle
Batch size = 100000 bottles
Setup time = 30 min

Total setup time = 3 * 30 min = 5400 s

Capacity = 10000/(5400 s + 0.2 * 100000)) = 3.937 bottle/s

3.937 bottle/s * 3600 s/h = 14173 bottle/h

Question 37 1 / 3 pts

Line manager Alex Klug proudly states: "In contrast to a serial production system without automated conveyors to transport the bottles from one station to the next one, my fully automated line avoids the 'buffer of suffer' issue." Is Alex right or wrong? Explain.

Buffer or suffer refers to a multi-step production system where setups in at least one of the steps reduces capacity so that the whole system either suffers from a loss of capacity or needs buffers to decouple the preceding and succeeding steps.

With the automated line, Alex does not have the possibility to stop producing in selected stages for setting them up with the others continuing in their processing. The whole line stands still while setups are performed. Therefore, Alex still suffers from a loss of capacity through setups.

Section VI

After 70% of the German population was vaccinated, the SARS-Cov-2 pandemic came finally to a halt. Unfortunately, the MERS-Cov-2 virus took over, causing an even more severe pneumonia than the SARS-Cov-2 virus. FS management decided to open a test center in a tent next to Frankfurt School's west entrance.

Question 38 2 / 2 pts

The center is staffed with one medical technical assistant who is able to conduct all required tasks. It takes exactly 6.2 minutes to test one customer. In average, 4.9 customers arrive per hour, whereby interarrival times are exponentially distributed. What is the utilization of the center? Please enter your result as percentage with two decimals, that is, 10.50 for 10.50%.

50.65

50.63

The correct answer is:

U= p/a = 50%

For example:

P = 6 min ; arrival rate = 5 customers/hour, hence interarrival time a = 12 min

U= p/a = 6 / 12 * 100 = 50.00%

Based on additional data, time to test one customer is updated to exactly 7 minutes. The interarrival time is determined as exponentially distributed with a mean of 10.3 minutes.

Given that customers are willing to wait, what is the expected average customer waiting time? Please enter your solution in minutes with two decimals.

7.42

7.42

The correct answer is determined using the waiting time formula.

Question 40

0 / 2 pts

Incidence is increasing so that demand for tests doubles. With all else being equal to the previous question, what is the expected customer average waiting time? Explain.

The correct answer is:

t-> infinite, because of u>=1

here you still have 1 server!

Question 41

1 / 2 pts

The test center reacts to the doubled demand by adding a second test station (also staffed with one employee). This station is in a tent outside the east entrance of Frankfurt School. What is the expected average customer waiting time with all else being equal to the question above?

When demand doubles and a second server is added, the waiting time at both test centers is the same as in the case calculated above with only one server and half of the demand. This assumes that demand splits equally between the two test centers.

2 stations.

Question 42

0 / 3 pts

FS operations management students suggest moving the 2 test stations in one big tent in front of the main entrance, so that a common waiting line is established. Time to test one customer is updated to constant 6.5 minutes. Interarrival times is determined as exponentially distributed with a mean of 5.7 minutes. What is the expected average customer waiting time with this new process layout? Please enter your solution in minutes with two decimals and explain your solution path below.

1.67

The correct answer is determined by using the waiting time formula.

Question 43

1 / 2 pts

Explain your solution path to your answer above.

Question 44

0 / 1 pts

Some time later in the year, the weather is getting so bad that people are no longer willing to wait outside. Instead, they leave and go to another center in town whenever both test stations are busy. At that time, on average 10 customers per hour arrive at the tent in front of the FS main entrance. The time to test one customer is constantly 6 minutes. How many people are leaving per day, when the center is open for ten hours per day? Explain your solution below.

20 (with margin: 0)

The correct answer is:

P=6min,

a=6min,

m=2,

r=p/a=1,

from Erlang loss table: P all two servers are busy(r=1)=20%;

100 customers coming per day; 20 customers lost per day

Question 45

0 / 3 pts

Explain how you solved the previous question.

Question 46

0 / 4 pts

Assume the same situation as in the previous question. Any lost customer costs the test center 100 EUR. Would adding a third test station increase profitability if the cost of a station per day is 200 EUR? Explain your solution path.

The correct answer is:

Old: lost profit = 20*100 EUR/day = 2000 EUR/day

New: p=6min, a= 6min; r=1, m=3; p all three servers are busy(r=1)=6.25%; customers lost per day= 6.25, lost profit is 625 EUR/day

Profit loss improvement is 1375 EUR/day, that is higher than cost of one more server, so add the third server.