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SPRING 2022

UGBA 141 Midterm Exam Solution

Name: _____ Student ID: _____

Instructions

SHOW ALL OF YOUR WORK on this exam. No credit is given on quantitative questions unless work is shown. Each question is worth 1 point and no partial credit is given (unless stated otherwise). No penalty for incorrect answers, so it is in your interest to answer all questions.

PLEASE WRITE YOUR ANSWERS WITH A PEN (NOT A PENCIL).

YOU MUST PUT YOUR FINAL ANSWERS INSIDE THE ANSWER BOXES TO BE GRADED.

Do not round answers unless requested to do so. Do not round intermediate calculations.

During the exam, you may not consult with anyone, and we will not answer any questions.

You may use one double-sided reference sheet of paper during this exam that does not exceed 8.5" x 11". You cannot share reference sheets with others.

You may use a calculator on this exam as long as the calculator cannot communicate with another device. Calculators cannot be shared with others. You may not use computers, tablets, cell phones, or any electronic device. All phones must be turned off.

To make your calculations as straightforward as possible, assume that, unless stated otherwise:

- There are sufficient parts or raw materials so that the initial operation(s) are never starved;
- Processing times have negligible variability, and over time, workers neither speed up nor slow down, but work always at the processing rates given;
- There are no machine breakdowns;
- When there are buffers shown, they are large enough to accommodate any amount of inventory that would reside in those buffers under normal operations;
- Travel time and time to transport parts from one operation to the next is negligible;
- All operations run with 100% yield, i.e., the operations produce no defective units; and
- All processes are in steady state (e.g., in the middle of the day); thus, you may ignore any start-up effects.

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A. The Cheesecake Factory (Q1-3)

The Cheesecake Factory (CF) has five Bay Area locations that were recently benchmarked against each other on the quality of the service (measured by food quality, courtesy, cleanliness, and other survey items) and the operating cost per meal served.

Restaurant	**Quality** (* = very low quality; ***** = very high quality)	**Operating cost per meal**
A. Corte Madera	***	$11
B. San Mateo	**	$5
C. San Francisco	*****	$20
D. Walnut Creek	****	$10
E. Pleasanton	*	$3

Q1. Which of these restaurants is not on the efficient frontier?

A. Corte Madera is dominated in both quality and cost by Walnut Creek.

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CF's most popular dish is *Cajun Jambalaya Pasta*. **For Q2-3**, we consider one location that serves only this menu item. Making this dish is comprised of 4 sequential steps:

- Preparing: 15 seconds per dish
- Boiling Pasta: 2 minutes per dish
- Cooking Chicken and Shrimp: 4 minutes per dish
- Plating: 1 minute per dish

The kitchen is staffed with 1 worker for Preparing, 1 person at each of the 4 Boiling stations, 10 highly-skilled chefs for one large Cooking area, and 1 person at each of the 4 Plating stations. Assume that dishes cannot be passed to the next step until the prior steps are completed.

The kitchen runs 10 hours per day, for 20 days a month. They receive orders for this dish for an average of 12,000 dishes per month.

Q2. What is the process capacity of this kitchen (in dishes per hour)?

Preparing = 1/0.25 *60 => 240 dishes/hr;
Boiling = 4/2 dishes/min => 120 dishes/hr
Cooking = 10/4 *60 => 150 dishes/hr;
Plating => 4/1*60= 240 dishes/hr;
Thus, Boiling is the bottleneck, and capacity of the kitchen is 120 dishes/hr.

Q3. What is the average labor utilization in this kitchen (XX.XX%)?

Labor content = 0.25 + 2 + 4 + 1 = 7.25 minutes
Demand rate = 60 dishes/hr <- demand constraint
Flow rate is 1/60 hour = 1 minute
Average labor utilization = (7.25 x 1) / (1 + 4 + 10 + 4) = 38.16%

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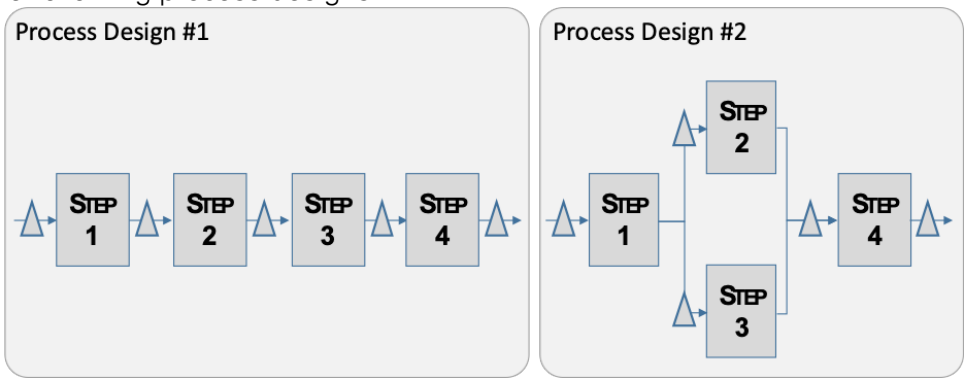
B. Two Process Designs (Q4-5)

Consider the following process designs:



In design #1, the four steps are performed sequentially: step 2 works on the output of step 1, and step 3 works on the output of step 2, step 4 works on the output of step 3.

In design #2, steps 2 and 3 work in parallel: steps 2 and 3 can start working on the unit as soon as step 1 is done, and unit moves on to step 4 once both steps 2 and 3 have been completed.

The two designs are otherwise identical in all respects. Assume that the first activity (Step 1) is the bottleneck and there exists unlimited demand.

Q4. Choose the correct answer:

A. Compared to Design #1, Design #2 has a higher labor utilization
B. Compared to Design #1, Design #2 has the same labor utilization
C. Compared to Design #1, Design #2 has a lower labor utilization
D. It cannot be determined

B because both processes are still constrained by Step 1 which is the bottleneck.

Q5. Choose the correct answer:

A. Compared to Design #1, Design #2 has a higher flow rate and a higher flow time
B. Compared to Design #1, Design #2 has a higher flow rate and the same flow time
C. Compared to Design #1, Design #2 has a higher flow rate and a lower flow time
D. Compared to Design #1, Design #2 has the same flow rate and a higher flow time
E. Compared to Design #1, Design #2 has the same flow rate and the same flow time
F. Compared to Design #1, Design #2 has the same flow rate and a lower flow time
G. Compared to Design #1, Design #2 has a lower flow rate and a higher flow time
H. Compared to Design #1, Design #2 has a lower flow rate and the same flow time
I. Compared to Design #1, Design #2 has a lower flow rate and a lower flow time

F because both processes are constrained by Step 1 (the bottleneck) which makes the flow rate the same. However, design #2 has a lower flow time since it has less inventory on average due to the parallel processing.

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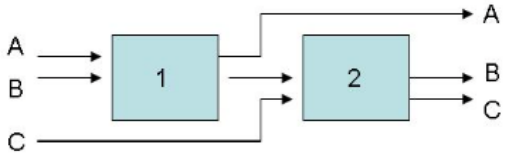
C. Edge Hair Salon, Berkeley (Q6-8)

Edge Hair Salon (EHS) offers three types of services: (A) haircuts, (B) chemical services (e.g., perms), and (C) waxing (e.g., eyebrows); each with its dedicated treatment room. There are currently 13 providers; all of them are trained as generalists (e.g., they can perform any of the currently offered services/tasks). EHS is known for their personalized and friendly service.

The following diagram shows the flow of 3 types of services (A, B, C) and two tasks (1, 2):



Job Type	Demand (jobs per hour)	Processing time (min) Task 1	Task 2
A	40	15	
B	10	12	5
C	25		8

	Task 1	Task 2
Staffing	8	5

Additional data regarding the process is provided in the tables. For example, Task 1 has 8 providers and Task 2 has 5 providers.

Q6. What is the implied utilization of the bottleneck (in %)?

Start with the capacity of the resource. We will use minutes of capacity per work-hour.

Resource	Number of Workers	Minutes of capacity per work-hour
Task 1	8	8 x 60 = 480
Task 2	5	5 x 60 = 300

Now create a demand table for each of the three types of jobs, A, B, and C

Resource	Workload for A	Workload for B	Workload for C	Total Workload
Task 1	40 jobs/work-hour * 15 min/job = 600 min/work-hour	10 * 12 = 120		600 + 120 = 720 min/work-hour
Task 2		10 * 5 = 50	25 * 8 = 200	50 + 200 = 250 min/work-hour

To get implied utilization, we divide workload by available capacity. Thus, the implied utilization of Task 1 is 720/480 = 150.0%. The implied utilization of Task 2 is 250/300 = 83.3%.

The bottleneck is Task 1 with the implied utilization of 150%.

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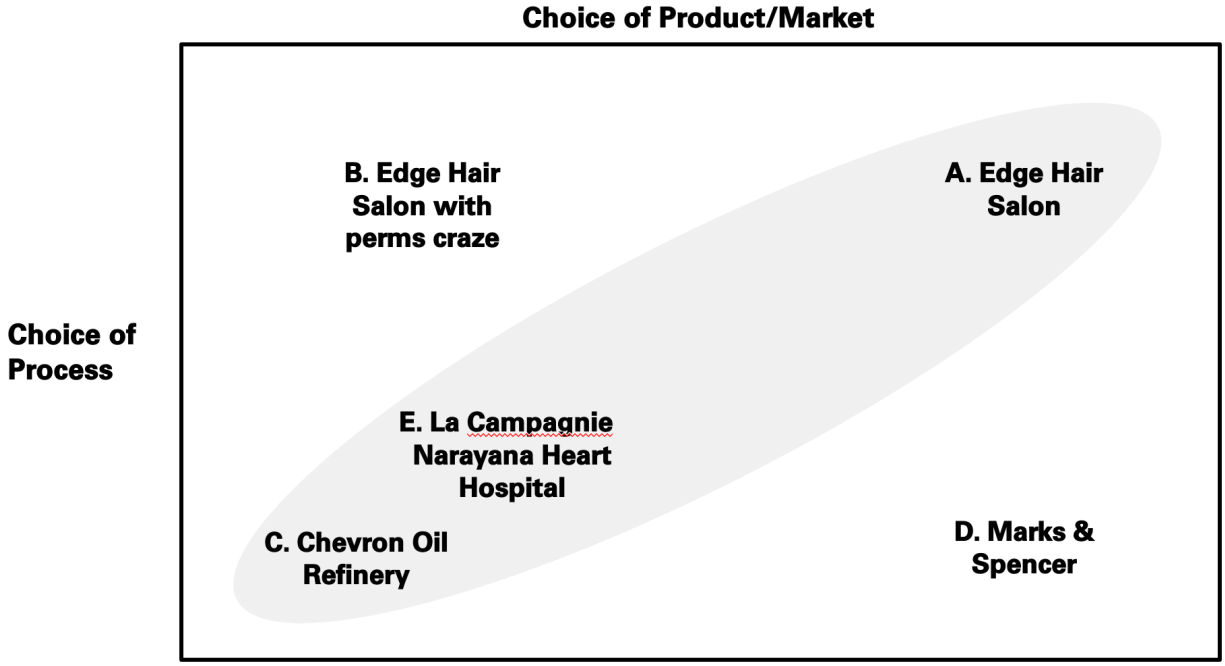
Q7. Put the following five companies (A-E) on the Product-Process matrix **(0.2 point for each)**

- A. Edge Hair Salon (Berkeley, CA) as described
- B. Edge Hair Salon (Berkeley, CA) when EVERYONE in the Bay Area goes there to ONLY get the latest K-pop perms →
- C. Chevron Oil Refinery (Richmond, CA)
- D. Marks & Spencer (London, UK)
- E. La Compagnie (Paris, France) – 100% business-class airline (only Paris and NYC)



Q8. For each of the following goals, describe an actionable process improvement strategy that EHS should employ. Be concrete and specific (No "standardize the process"). **(0.5 point each)**

a. Increase capacity of the bottleneck without hiring more providers (~Beleza Natural)

Move staff from underutilized resources to help with the bottleneck task
Re-train staff to specialization

b. Avoid certain hairstyles being "saturated" (~Zara)

Intentionally make the hairstyle "stockout" by understocking products for that style/understaffing the service

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D. Oakland International Airport (Q9-10)

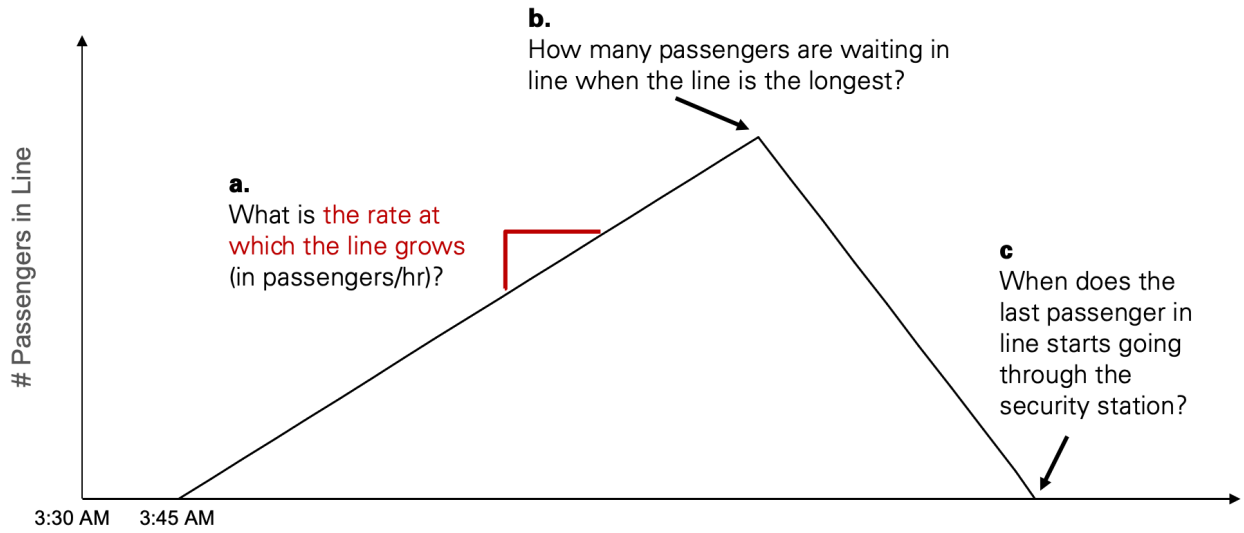
The Oakland International Airport (OAK) is initiating a new set of early morning flights.

- 4 new flights, all departing at 6:00 a.m., will be the first flights of the day.
- There are no other departures until 12pm.
- Each plane has exactly 150 passengers. No no-shows/cancellations.
- For each flight, passengers begin arriving 2 hours and 15 minutes before the scheduled departure and continue arriving until 45 minutes before departure; they arrive steadily.

OAK is determining the number of security stations to handle this new set of flights.

- Each security station can process 90 customers per hour.
- Each passenger must begin security processing 20 minutes before the scheduled departure to make her flight. It is required that all passengers must make their flights.
- Total cost of one security station is $500 / operating day (from 0am to 11:59pm).
- OAK cares not only about the station's cost, but also about the experience of passengers. The passenger waiting cost is incurred at a rate of $3/passenger/hour.

Q9. The first proposal is to have 3 stations. Below is a partial inventory buildup diagram.



a. What is the rate at which the line grows? (in passengers per hour) **(0.25 point)**

Arrivals: 600 passengers per 90 minutes → 400 passengers per hour
400 – 270 customers/hr = 130 passengers/hr

b. How many passengers are waiting in line when the line is the longest? **(0.25 point)**

130 customers arriving per hour over a 1.5 hour arrival period = 195 customers in line

c. What time does the last passenger in line start going through security? **(0.5 point)**

Slope decreases at rate of 270 customers per hour = 3 security stations x 90 customers served per hour.

195 customers in line / 270 customers processed per hour = 0.72 hours = 0.72 x 60 = 43 minutes after 5:15 AM to process remaining customers -> 5:58 AM

Q10. The second proposal is to have 5 stations. Answer the following: **(0.5 point each)**

a. How many passengers are waiting in line when the line is the longest?

Zero

b. Between the two proposals (3 vs 5 stations), which one should be adopted by OAK? Justify your recommendation.

Among the two, they should go with getting 5 stations. The 3-station idea doesn't make sense since some passengers will be forced to miss a flight.

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E. Campbell Soup Company (Q11-15)

The weight printed on Campbell's Chicken Noodle Soup can is 100 grams. However, it is difficult for the filling equipment to put exactly 100 grams into the can. Management sets a lower specification limit of 100 grams (complying with the FDA) and an upper specification limit of 110 grams (not giving away too much free food). Due to the large number of cans processed, the plant does not retain the data on weights. The operators have collected the weights of 4 consecutive cans for each of 5 different shifts.

Shift	Sample 1	Sample 2	Sample 3	Sample 4	X-bar	R
1	103	102	111	104	105	9
2	104	102	107	99	103	8
3	115	101	104	108	107	14
4	107	106	101	102	104	6
5	98	112	104	110	106	13
				Averages	105	10

std dev of values from the 20 different samples = 4

Q11. What is the capability index of this process? (Keep four decimals)

(110 - 100) / 6 * 4 = 10/24 = 0.4167

Q12. Is there any indication that the process's average weight is out of control? Show your work (i.e., control limits) and justify.

For X-bar, UCL = 105 + 0.729 (10) = 112.29
LCL = 105 = 0.729 (10) = 97.81 none of X-bar values is out of control

Q13. Is there any indication that the process's probability of defective cans is out of control? Show your work (i.e., individual p-values and control limits) and justify.

Shift	Sample 1	Sample 2	Sample 3	Sample 4	X-bar	R	p
1	103	102	111	104	105	9	0.25
2	104	102	107	99	103	8	0.25
3	115	101	104	108	107	14	0.25
4	107	106	101	102	104	6	0
5	98	112	104	110	106	13	0.5
				Averages	105	10	0.25
std dev of individual weights = 4							

For p, $UCL = 0.25 + 3\sqrt{\frac{0.25(1-0.25)}{4}} = 0.8995$

$LCL = 0.25 - 3\sqrt{\frac{0.25(1-0.25)}{4}} < 0$ so set to 0 none of p values is out of control

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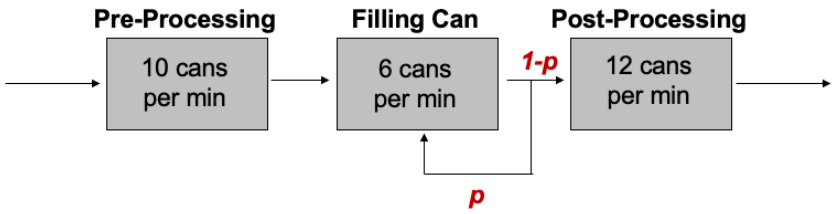
For Q14-15. If the actual weight is outside the specification range, the plant discards the soup and re-fills the can. Let p be the probability that a can is defective (and needs to be re-filled). The flow diagram of this process is shown below:



Q14. Assume that the weight of each can is independently and identically drawn from a Normal distribution with a mean of 105 grams and a standard deviation of 4 grams.

What is the probability of re-filling, p (in XX.XX%)? (Hint: Below and above are symmetric.)

P(rework) = P(weight below 100) + P(weight above 110)
Z-score for below = (100 - 105)/4 = -1.25 -> P(below) = 0.10565
Z-score for above = (110 - 105)/4 = 1.25 -> P(above) = 0.10565 (symmetric)
P(rework) = 0.10565 x 2 = 0.2113 = 21.13%

Q15. Assume that the can that goes through the re-filling step will always be within the specification limit (e.g., no cans go through the filling step more than twice).

Using the re-filling probability from Q14, what is the capacity of this capacity-constrained process (cans per minute)? Keep 4 decimals.

6 cans per minute = 10 seconds per can
P = 21.13%, processing time = 20 seconds per can
P = 78.87%, processing time = 10 seconds per can
Average processing time = 12.1130 seconds per can
Process capacity = 1/average processing time = 60/12.113 = 4.953359 cans per minutes

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F. Qualitative Operational Strategies (Q16-18)

Q16. (0.5 point) Name one strategy that is used by both Nhiem Nguyen's data center operations at Meta (formely Facebook) and Zara.

Vertical Integration

Q17. Describe how sustainability practices (**choose one:** environmental or social practices) can lower operating costs by using Starbucks' practices discussed in class as an example.

Environmental: Plant-based food costs less (introducing Beyond Meat). Greener store helps save energy costs. New lid design means less need for straws.

Social practices: Maintaining safe, fair, and human work environment improves well-being and thus lead to more productivity. (C.A.F.E. practices)

Q18. (2 points) Match Ritz-Carlton service practices to relevant Lean/TPS concepts by writing the practice indices (A-H) under the corresponding columns. Each practice will be matched with only one concept; however, each concept can be matched to any number of practices. (Each correct match is worth 0.25 point.)

Ritz-Carlton Practices:

A. Daily 15-minute line-ups
B. Hotel restaurant can switch between serving dine-in customers and room service at no cost
C. Grammarly (a cloud-based typing assistant) is installed on all client-facing email accounts
D. High-end elevators with state-of-the-art door sensors
E. Continuously analyzing the DQPR data
F. Balanced cleaning schedule for different types of rooms
G. Closing the gym for review right away when a guest complained about a broken machine
H. Work authorization app that limits the amount of "anticipation" tasks among employees

Lean/TPS Concepts:

Poka-Yoke	Jidoka	Just-in-Time	Heijunka	Kaizen
C. Grammarly D. Elevator	G. Closing the gym	H. Work authorization app	B. Hotel restaurant F. Balanced cleaning schedule	A. Daily lineup E. Analyze DQPR data

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G. Kristen's Boba Empire (Q19-23)

Kristen owns 4 boba (bubble tea) shops of similar size. Currently, she faces the problem of employee absenteeism. For each employee short, profits decline by $50. To deal with this problem, Kristen has identified several retirees who are willing to fill in for absent employees as "on-call" employees. Every evening, she calls the specific retirees who will be on-call the next day. Any on-call employee for the day can get 2 free drinks (which cost the shop $10 for two free drinks), even if the regular employee does show up to work. The need for on-call employees on a typical day at each shop is independent and identically distributed as a Normal distribution with a mean of 2 employees and a standard deviation of 1 employee.

Q19. If Kristen operates the on-call employee staffing independently for each shop (e.g., using a dedicated pool for each shop), how many on-calls she should staff in total across four shops?

Gain = $50 that we can save from serving one customer
Loss = $10 (the two meals)
Critical ratio = 50/60 = 0.833, z = 0.97
Daily demand for one restaurant: mu = 2, sigma = 1
Number of on-call employees = 2 + 0.97*1 = 2.97 -> round to 3 per restaurant.
Separate system: 3 x 4 = 12 on-call employees

Q20. (1.25 point) If Kristen instead uses a shared pool of on-call employees for all four shops and decides very last minute which location to assign to each confirmed on-call employee, how much money can she save on free drinks for on-call-employees?

Pooled system: mu = 4x 2 = 8, sigma = sigma(4) = 2
Number of on-call employees: 8 + 0.97*2 = 9.94 -> round up to 10 on-demand employees
Ms. Burger can save 2 x $10 = $20 per day by using the pooled system.

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For Q21-23: Kristen recently expanded her business to sell boba-themed Lego toys at one of her shops that opens 350 days per year. Daily demand averages 300 units and has a standard deviation of 60 units (~Normal). Kristen uses an annual holding cost rate of 80% for her goods.

Her contract with Lego: she pays $8 per unit and sells a unit for $10. Lego charges $750 per cargo flight for each delivery. Each cargo flight can hold up to 5,000 boxes and takes 4 days to deliver. According to the terms of the contract, the order quantity is restricted to be a multiple of 100. Suppose Kristen wants to maintain a 98% service level.

Q21. What should the order quantity *Q* (in units) be?

Q = multiple of 100's
Cost for sending one truck = $750, one truck per order
Q = EOQ = sqrt (2 x 750 x 105,000 / 0.8 x 8) = 4960 EOQ -> round it up to 5,000 boxes

Q22. (1.25 point) What should the reorder point *R* (in units) be? Round up to the next integer.

C = $8, selling price = $10, D = 300 / day * 350 days = 105,000 / year
Lead time = 4 days, H = 80%

For daily demand: mu = 300, sigma = 60
Demand during lead time = 300 x 4 = $1,200
SD during lead time = 2 x 60 = 120

Service level of 98%, Q= z = 2.06 -> R = muLT + zSDLT = 1,200 + 2.06 (120) = 1,447.2
-> 1,448 boxes

Q23. If on average a boba-themed Lego toy spends 35 days in Kristen's shop before it is sold, what are the annual inventory turns for the boba-themed Lego toy?

350/35 = 10