MSIN0095 Operations Analytics

Online Controlled Examination Paper 2022/23

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<table>
<tr><td>Exam Length</td><td>THREE (3) hours</td></tr>
<tr><td>Number of Sections</td><td>There are THREE (3) sections to the examination paper.</td></tr>
<tr><td>Question/Mark Distribution</td><td>There are 8 questions in this exam. Each question has multiple parts. Answer ALL of the questions for a total of 148 marks. Below is a breakdown of the marks:

<table>
<tr><td>Question:</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>Total</td></tr>
<tr><td>Marks:</td><td>17</td><td>21</td><td>13</td><td>17</td><td>26</td><td>33</td><td>12</td><td>9</td><td>148</td></tr>
</table>

Although marks for each question may indicate the difficulty, it does not indicate the time you should spend on each question.</td></tr>
<tr><td>Additional Materials</td><td>Standard Normal Distribution Table provided at the end of the paper on page 18.</td></tr>
<tr><td>Handwritten answers permitted?</td><td>Yes</td></tr>
<tr><td>If yes, where are handwritten answers permitted</td><td>Please ensure that any handwritten answers are clear and legible. Illegible work will not be marked.</td></tr>
<tr><td>Other notes</td><td>You should include the steps/working out in your answers to gain full marks.

If you are unclear on any part of the question, state your assumptions in your answers.</td></tr>
<tr><td>Module Leader:</td><td>Mengzhenyu Zhang</td></tr>
<tr><td>Internal Assessor:</td><td>Dongyuan Zhan</td></tr>
</table>

QUESTION 1: Truck Safety Inspection

A truck safety inspection station is operated by a single inspector who can inspect at most one truck at a time. On average, 24 trucks arrive at the station in an hour, and an average inspection takes 1.5 minutes once the inspector begins examining the truck. The truck interarrival times and inspection times are both exponentially distributed.

a) What is the utilization of the inspection station?

[3 marks]

A = 2.5
P = 1.5

Utilisation = p/a = 1.5/2.5 = 60%

b) How long on average does a truck spend waiting in line prior to its inspection (in minutes)?

[3 marks]

A = 2.5 ,p = 1.5 ,u = p/a ,Cva =1 ,Cvp = 1
VUT = ((CVa)^2 +(CVa)^2)/2 * ((U)/1-(U))* p
VUT = 1* ((0.6)/1-(0.6))* 1.5 = 2.25 min

c) The manager sets the requirement that at least 8 out of 10 arrivals should find waiting space for waiting trucks available. At least how many waiting spaces for waiting trucks (not including the one being inspected) does the station need to provide in order to meet the requirement?

[3 marks]

80% = u^n
20% = 0.6^n
We therefore solve for n
Log(0.2) = log(0.6^n)
n*log(o.6) = log(0.2)
n = log(o.2)/log(0.6) = 3.15

We have just calculated the number In the system, to get the number of people waiting, we need to take n and substract 1
n-1 = 2.15. we therefore round up in order to get 3 spaces in the queu

Continued

d) After the inspector gains some experience, the inspection times become exactly 2 minutes, with no variability. If all else remains the same, we expect the system average inventory to Increases (*increase/decrease/stay the same*).

[3 marks]

A = 2.5 ,p =2 ,u = p/a ,Cva =1 ,Cvp =0
VUT = ((CVa)^2 +(CVa)^2)/2 * ((U)/1-(U))* p
VUT = 4 min
Total Inventory = 4+2/2.5 = 2.4
Total
Inventory question b = 2.25 + 1.5/2.5 = 1.5
With more waiting time, the inventory increases

e) The crew cost is approximately $300 per day. The cost associated with lost productivity from the breakdown is estimated at $150 per vehicle per day (or any fraction thereof). The mechanic crew can now repair 11 vehicles per day, which will lead to an average waiting time of T_q = 93.5 min. Assume the same arrival rate as before. Adding a second crew that works as fast as the old crew (still operating with one single queue) will make the total daily cost _____ (*increase or decrease*) by _____.

[5 marks]

Assume a 12 hour day

crew = 300 per day **TOTAL: 17 Marks**
Tq = 93.5
Rp = 11 per day
A = 2.5min

Cost for one crew(daily) = 300 + 11 *150/720 *93.5 = 514, 2 dollars

Cost of 2 crews
Rp = 22
We devide Tq by 2 so Tq = 46.75
Cost = 2*300+11 *150/720 *46.75 = 707.135
So we can say that it increased by 192,93

Question 2: Rags2Riches

Rags2Riches (R2R) sells handwoven bags created by trained artisans living in impoverished neighborhoods in the Philippines. R2R curates an online website from which a customer can purchase one of its many handbags, backpacks, or purses. To ensure that it can deliver in time to its customers, R2R keeps inventory of its most popular products in a fulfilment centre. Whenever a replenishment is needed, it places an order from a local supplier who can deliver within a few hours. The cost of placing an order is $1000 per order. R2R has an inventory holding cost of 30% per year. The company operates 360 days per year.

One of R2R's best-selling items is the Buslo bag, which retails for $125 per bag. The supplier charges R2R a unit procurement cost of $30 for each Buslo bag it orders. Suppose that R2R sells always three Buslo bags a day.

Continued

a) Suppose that R2R decides to order exactly four times a year, how many Buslo bags should it order each time to minimize inventory holding cost without ever running out?

[3 marks]

We calculate EOQ

D = 3*360 = 1080/year
EOQ = SQRT(d*2*S/H)
EOQ = sqrt(2*1080*1000/0.3*30) = 489,89

D/4 = 270
270 units per year

b) Suppose that R2R decides to order 350 units each time. What is the smallest annual inventory holding cost that R2R can incur without ever running out?

[3 marks]

Annual holding cost Q/2*h
= (350/2)*9
= 1575

c) What is the optimum order size?

[3 marks]

D = 3*360 = 1080/year
EOQ = SQRT(d*2*S/H)
EOQ = sqrt(2*1080*1000/0.3*30) = 489,89

d) Suppose that R2R decides on an order size of 350 units. Now, the supplier takes 30 days before delivering the order to R2R. What should the fulfilment centre inventory level be at the time point when R2R places an order so that it does not incur backorders or have excess inventory before the order arrives?

[3 marks]

ROP=D*L = 3*30 = 90

Continued

R2R also sells the Buena zip coin purse. The daily demand for this item is normally distributed with a mean of 10 units and a standard deviation of 3. R2R decided to partner with the Buena supplier so that it can place an order at the beginning of each Monday, and R2R does not incur a fixed cost for ordering. It takes five days before an order placed arrives at R2R, and R2R pays upon placing an order. R2R would like to have a service level of 90%.

e) What is the optimal average safety stock of Buena coin purses that R2R should have?

[3 marks]

T+L = 12 days
Sd = 3* sqrt(12) = 10,39
Z = 1.2816
SS = 1.28*10.39 = 13.3188

f) What is the average cycle stock of Buena coin purses?

[3 marks]

Average cycle inventory = ud *T/2
Average cycle inventory = 10* 7/2 = 35

g) Suppose that R2R decides to have a target stock level of 60. Today is a Monday and there are 2 people in the waiting list for a Buena coin purse. How many units of the coin purse should R2R order today?

[3 marks]

Total average inventory = SS + cycle Inventory = 13.52 + 35 = 48.51
Order Qu = TS - average = 60-48.51 = 11.49

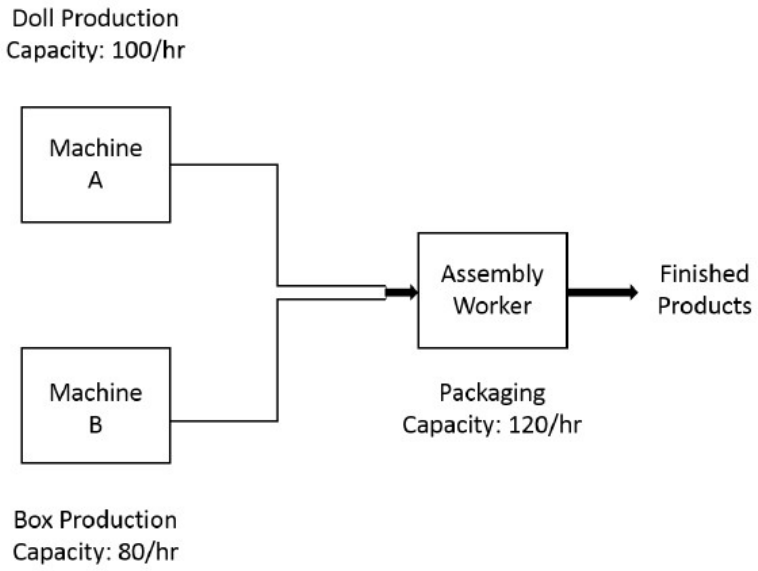
TOTAL: 21 Marks

Continued

Question 3: UCL Toy Factory

UCL Toy Factory is setting up a production line for a new model of the toy dolls. The production line is depicted in the figure. It is an assembly process with two machines and a worker: machine A produces the toy dolls at a rate of 100 units/hr; machine B produces the boxes for the dolls at a rate of 80 boxes/hr; the assembly worker takes one doll and one box and packs them together to produce one unit of the finished product. The worker can produce the finished products at a rate of 120 units/hr.

Figure 1: The Production Process for Toy Dolls



a) What is the capacity of the whole production process?

[2 marks]

Rate of bottle neck = maximum capacity rate
Machine B is the bottleneck

Capacity rate = 80 units per hour

Last month, the manager of UCL Toy Factory received lots of complaints regarding the quality of the dolls, so he hired a quality engineer to examine this issue. The engineer found that the height of the dolls produced by Machine A had large variability. Specifically, the doll height is normally distributed with an average height of 11.5 inches, and a standard deviation of 0.5 inches. The quality engineer learned from the design team that the lower tolerance limit (LTL) and the upper tolerance limit (UTL) for the height are 11 and 12 inches, respectively. Based on this, the quality engineer set up a quality examination procedure that happens right after the doll production and before the dolls get packed by the assembly worker. Any doll with the defect in height (either too tall or too short) will be discarded. The examination procedure works very fast so it will not be the bottleneck.

b) What is the defect rate of Machine A?

[3 marks]

$Z = ((12-11.5)/0.6) = 1$

We find the probability using the Z score
$P(x<LTL) = 0.1587$
$P(x<UTL) = 0.1587$

Defect rate = $P(x<UTL) + P(x<LTL) = 0.3174$

c) Suppose that the defect rate of Machine A was found to be 23%. What is the process' maximum throughput rate of toys?

[4 marks]

Unafected machine A capacity = 1- 0.23 = 0.77

0.77 is the bottleneck

Max througput rate = 77 units per hour

UCL Toy Factory has another production line that produces a smaller version of the toy dolls. The production process and all the capacity parameters are the same as in Figure 1. For this smaller version, the doll height should be within 8±0.25 inches. Currently, these smaller dolls are produced by Machine A with an average height of 8 inches, with a standard deviation of 0.31 inches. Assume that the doll height is normally distributed.

d) Machine A is the bottleneck with the current defect rate of 42%. What is the largest acceptable standard deviation of doll heights in order for Machine A to NOT be the only bottleneck of the whole process?

[4 marks]

TOTAL: 13 Marks

Unaffected machine a capacity = 80 units/ hour

Requiered defect rate = (100-80)/100 = 20%

Z = 1.2816

So 1.2816 = 0.25/SD

We can solve for the standard deviation

SD = 0.195

Continued

Question 4: Favors Distribution Company

Favors Distribution Company (FDC) purchases small imported trinkets in bulk, packages them, and sells them to retail stores. The managers are conducting an inventory control study of all their items.

The following 2017 data are for its line of scented soaps, which is not seasonal.

Month Index	1	2	3	4	5	6	7	8	9	10	11	12
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sales	51	54	57	60	63	66	69	72	75	78	81	?

a) Using a trend projection, estimate the relationship between time and sales (state the equation).

[3 marks]

Y = ax + b
Sum of all of the X's = 66
Sum of all of the y's = 726
Mean of x = 6
Mean of Y = 66
G = 110, h = 330
B = (H/G) = 3
We solve for a using a value a = 48 conclusion = Y = 48+ 3x

b) Suppose that the estimated trend is Sales = 30 + 1.5 × Month Index. Last month (November 2017), the sales was 45 units. Using the trend method, what is the projected sales for March 2018?

[3 marks]

40 = 30 + 1.5x
Month index of x would be march 2018 and would be 14
The sales in march 2018 are therefore 30 +1.5 *14 = 51 units

One of its most popular items are Detroit fridge magnets being sold at the Detroit Metro Airport. FDC tracked the daily sales at the airport over the last four weeks. The data shows little in terms of trend, but do display substantial variation by day of the week.

	Week 1	Week 2	Week 3	Week 4
Sunday	40	35	39	43
Monday	54	55	51	59
Tuesday	61	60	65	64
Wednesday	72	77	78	79
Thursday	89	80	81	79
Friday	91	90	99	95
Saturday	80	82	81	83

c) From the data, the company determined that an average day's demand is 70 units. Since there is no evidence of trend, you can assume that an average day's demand is the same all throughout the four weeks. What is the typical seasonal index of a Monday?

[3 marks]

We can calculate the specific seasonal index for monday as such
Week 1 : 54/70 = 0.77
Week 2: 55/50 =0.78
Week 3: 51/70 =0.73
Week 4: 59/70 = 0.84

d) Suppose that the typical seasonal index of a Friday is 110. If the Week 5 Friday sales is 93 units, what is its corresponding deseasonalized sales?

[3 marks]

The Si of a friday is 110
Deseasonalized sales = 93/110 *100 = 84.54

FDC decided to add a limited edition Christmas ornament to its offerings. The retail price of the ornament is $20, and the unit cost is $12.50. At the end of the selling season, the ornament can be sold at 10% of its selling price.

Although the demand for limited edition Christmas ornaments from previous years is variable, the company thinks that there is no significant trend nor were there any cycles in sales of the past ten years. Below is the sales data from the past ten years.

Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Sales	10	12	9	11	13	14	10	15	9	11

e) How many units of the Christmas ornament should FDC order to maximize the expected profit?

[5 marks]

TOTAL: 17 Marks

We calculate the cumulative probability.
X, p(x), cumulative probablity
9 0.2 0.2
10 0.2 0.4
11 0.2 0.6
12 0.1 0.7
13 0.1 0.8
14 0.1 0.9

Find co and Cu
Cu = 20-12.5 = 7.5
C0 = 12,5-2*10 = 10.5

SL = 0.4166

Conclusion:

When demand is 11, the cumulative probability is 11 units

Continued

Question 5: Crane Mountains Parkas

To ensure a full line of outdoor clothing and accessories, the marketing department at Crane Mountain, a full time of outdoor clothing and accessories chain, insists that they sell high-tech winter parkas. Unfortunately, Crane Mountain does not have expertise in manufacturing those kinds of parkas. They found a Canada-based supplier, Moose Knuckles, that was able to provide a quote of $275 per parka. Moose Knuckles can manufacture parkas at a cost of $150 per parka.
Crane Mountain knows that it cannot sell the parkas for more than $350. Given the retail price, Crane Mountain's demand forecast is for 600 parkas (normally distributed), with a standard deviation of 300. In addition, Crane Mountain anticipates excess inventory will need to be sold off at a 75% discount at the end of the season.

a) If Crane Mountain decides to include these parkas in its assortment, what is the optimal service level it should target to maximize expected profits?

[3 marks]

Co = 275 – 350*0.25 = 187.5
Cu = 350 – 275 = 75
SL = 28.57%

b) Crane Mountain's marketing department conducted a study of the market for high tech parkas. They decided that they can increase their revenues by increasing the retail price of parkas to have an optimal service level of 40%. Given the new price, Crane Mountain's demand forecast is for 400 parkas (normally distributed), with a standard deviation of 300. How many parkas should Crane Mountain keep in stock?

[3 marks]

Z value = -0.25
D = 400, SD = 300

300*(-0.25) +400 = 325

c) Suppose that Crane Mountain decides to keep an inventory level of 200 parkas. What is Moose Knuckles' profit?

[2 marks]

Cost for per parka 1 = 150
Cost per Parka2 = 275
Profit per Parka = (275-150)*125
Moose knukkle total profit = 25000

Continued

d) What is the optimal service level for this two-tier supply chain? (i.e., maximizes the expected profit of Crane Mountain's and Moose Knuckles).

[4 marks]

Critical ratio = 75/(75+275-b+25)
To calculate b, we do the following calculation
B = 0.8 * (75+275-b+25) = 75, b = 281.25

e) Suppose that the retail price of parkas is $350. In order to encourage Crane Mountain to increase its order of winter parkas, Moose Knuckles proposes a buy-back contract. Under the contract, Moose Knuckles would buy back any unsold parkas at the buy-back price. A shipping cost of $25 per parka is incurred by Moose Knuckles. Supposing that the optimal service level for the two-tier supply chain is 80%, at what buy-back price would Crane Mountain's optimal service level be equal to the optimal service level for the chain?

[5 marks]

Average demand = 400

Standard deviation of demand = sqrt(100**2+100**2) = 141,42

We know that z-score = 2.05

2.05*141,419 = 289.91

Total = 289 + 400 = 689.91

f) Crane Mountain has realised that while some customers like hooded parkas and appreciate the hooded version of the high-tech parka, others don't like it. Suppose the demand for the hooded and un-hooded versions of the parka are independent from each other and are both normally distributed with mean 200 and standard deviation 100. Instead of ordering the two versions separately, Crane Mountain is considering ordering a "generic parka" and add the hood on demand (free of charge) in the store. The design is such that this option would not affect how the un-hooded version looks. Suppose the company would like to keep the same service level for the individual as well as generic parkas at 98%. With this option, ignoring the inventory of hoods that are added later, what happens to the total inventory of the parkas at the beginning of the winter season?

[5marks]

ordered = 850 and the revenue = 650*275 = 178750
Sold = 650
cost = 650 *150 = 97500
Unsold = 200,
Shipping cost = 650 * 25 = 16250

Revenue for the buyback = 200**2 = 40000

The shipping costs are therefore = 200*25 = 5000

Continued

Given a buy-back contract with buy-back price of $200, Moose Knuckles decides to order 850 parkas. At the end of the winter season, Crane Mountain was able to sell 650 parkas. With the buy-back contract, what is Moose Knuckle's profit at the end of the season? Suppose that there is no salvage value to Moose Knuckles for any unsold parkas, and a unit shipping cost of $25 is incurred by Moose Knuckles.

g) Crane Mountain also rents out tents for outdoor enthusiasts. A major music festival weekend is expected to occur next month during which tent rentals are in high demand. Customers decide to rent a tent one month in advance. Crane Mountain has a total of 100 tents available for rental. Customers pay a non-refundable $30 to rent a tent for the weekend. Based on past data, Crane Mountain estimates that on average 15 customers who have paid for the tent would not show up to collect their tent (Normally distributed with a standard deviation of 15). If a customer with reservation shows up, but there is no tent for them, Crane Mountain offers them a new, smaller tent for free without the need to return—an option that all customer would accept happily. The smaller tent costs Crane Mountain $100. How many reservations should Crane Mountain accept?

[4 marks]

TOTAL: 26 Marks

Question 6: Friendly Greetings

The Friendly Greetings greeting card company outsources printing to a nearby printing shop, which charges a $1200 fixed charge to start producing a design of card, then $0.30 for each card produced. The printing shop turns around production orders quite quickly, so lead-time can be considered negligible.

Demand for birthday cards of a certain classic design has long been at a constant and steady rate of 25, 000 cards per year. Friendly Greetings stores cards in its own warehouse. The company estimates holding costs to be 5 cents per card per year, including variable warehousing costs and the opportunity cost of capital.

a) The company's current ordering policy is not necessarily optimal. They place an order for 15,000 cards when their stock of cards is zero. How much do they spend annually on fixed production charges for the birthday card design?

[3 marks]

Number of orders per year = 25000/15000 = 1.67

2 orders per year 2*1200 = 2400 dollars

Continued

b) Given their current ordering policy (order 15, 000 cards when inventory is zero), what is their annual holding cost for this particular design?

[3 marks]

Anual holding cost = (15,000/2)*0,05= 375

375 * 1.67 because that's the nbr of orders per year

= 625 dollars

c) Given their current ordering policy (order 15, 000 cards when inventory is zero), how long (in years) does an individual card spend in the Friendly Greetings warehouse on average?

[3 marks]

d) What is the optimal EOQ for the birthday card?

[3 marks]

We calculate EOQ

EOQ = sqrt((2*25000*1200)/0.05)
EOQ = 34642

e) Now suppose that the print shop requires a 2-week lead-time to turn around a production order. What is the optimal reorder point for the card? (You may assume 50 weeks in a year.)

[3 marks]

L = 2 weeks = 14 days
ROP = D*L+SS
ROP = 25000 *(2/50)
ROP = 1000 cards

f) Suppose again that the print shop requires a 2-week lead-time to turn around a production order. Now suppose that weekly demands for the card are independent and follow the normal distribution with a standard deviation of 60

cards. The average demand rate is unchanged. Now, Friendly Greetings decides to order every 15th day of the month and the order is paid whenever it is placed. The company would like to have a service level of 80%. You may assume 4 weeks in a month and 48 weeks in a year. What is the long run average total inventory?

[4 marks]

Weekly demand = 60
With 80 percent service level, z = 0.84
Total inventory = ½ * uo*T+ SS + u0L
T = 4
U0 = 25000 per year
SS = Z * sd * sqrt(L+T)
SS = 0.84*60*sqrt(4+2)
SS = 123, 45
Total inventory = ½ * (25000/ 48) * 4 +123,45+ (25000/48)*4 = 3248,45

g) In the previous question, what service level (during lead-time period L) is implied if Friendly Greetings places an order when their inventory of cards hits 1120?

[10 marks]

We want to find the Z
ROP = 1120
ROP = D*L + SS
SS = z * sd + sqrt(T+L)
In the above equation, we have everything apart from Z
By solving for Z we get 0.533
Service level = 70.2 %

h) Suppose that, if a customer wants a birthday card when Friendly Greetings is stock out, the sale is lost. Friendly Greetings still orders every 15th day of the month. What is the stockout cost implied when the company decides to provide a service level of 80%? Assume Friendly Greetings used an appropriate model from class to determine the optimal service level. You may assume 4 weeks in a month and 48 weeks in a year. There are 12 months in a year.

[4 marks]

TOTAL: 33 Marks

Question 7: Box Office

Tickets for the new Herbinators concert went on sale last Saturday morning at the United Centre box office. Customers arrived at the United Centre at a steady rate of 300 per hour starting at 5am until noon, and a queue formed in front of the box office. There was no balking or reneging. At 9am, the box office opened and began selling tickets through 8 ticket windows, each of which served customers at a steady rate of 60 per hour. The box office closed at noon, at which point all remaining customers in line were turned away.

Continued

a) How many customers did the box office serve on Saturday morning?

[3 marks]

a = 300/hour ,p = 60/hour ,u = p/a ,Cva = 0 ,Cvp = 0

3*(60*8) = 1440

Their are 1440 customers served on saturday morning

b) How many customers were in line when the box office closed?

[3 marks]

5 – 12 : 7*300 = 2100
9 – 12 : 3*60*8 = 1440
2100 – 1440 = 660

Their are therefore 660 customers in line

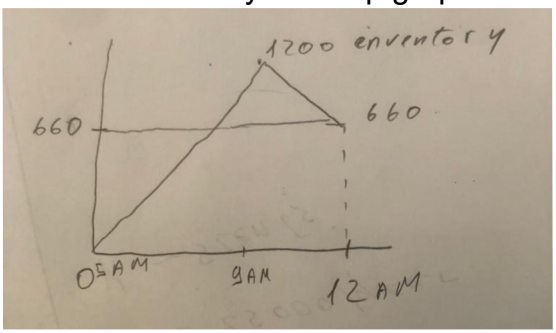
c) How many customers were in line when the line was at its longest?

[3 marks]

Longest is before 9 am (the open time)
4*300 = 1200
There were therefore 1200 customers in line

d) What is the inventory build-up graph?

[3 marks]



TOTAL: 12 Marks

Question 8: Warehouses

A mail-order firm has four regional warehouses. Demand at each warehouse for a particular item is normally distributed with a mean of 10,000 per week and a standard deviation of 2,000. Annualized cost of capital is 25%, and each unit of product costs the company $10. Each order incurs an ordering cost of $1000 (primarily from fixed transportation costs), and lead time from the supplier is 1 week. The company wants a 95% service level. Assume 50 working weeks in a year. Inventories can be monitored and managed in continuous time.

Continued

a) Assume that each warehouse operates independently. What should be the ordering policy at each warehouse?

[3 marks]

D = 10,000, Std = 2,000
Unit cost = 10
capital cot = 25%
L = 1 week , SL = 95% , z = 0.8289
50 working weeks in a y
EO Q. = SQRT (2 * 500 000 *1000 / (0,25 *10) =
= 20000

b) Given the policy, you computed in part (a.), how much inventory does each warehouse hold on average?

[3 marks]

average inventory level 1/2 * EOQ + SS
safety stock = 3290 units.
Inventory level = EOQ/2 + SS = 20,000/2 + 3290 = 11,29

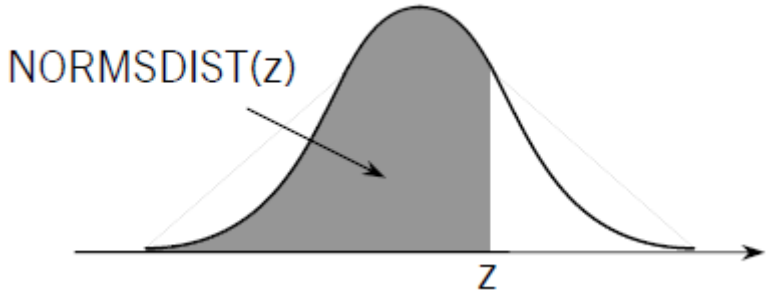
Each warehouse holds 11,290 units

c) Now assume that the firm has centralized all inventories into a single warehouse. What should be the ordering policy for the central warehouse?

[3 marks]

TOTAL: 9 Marks

Standard Normal Distribution Table



(a) Find probability from z

z	NORMSDIST(z)	z	NORMSDIST(z)
0	0.5	3.3	0.999516576
0.1	0.5398	3.4	0.999663071
0.2	0.5793	3.5	0.999767371
0.3	0.6179	3.6	0.999840891
0.4	0.6554	3.7	0.999892200
0.5	0.6915	3.8	0.999927652
0.6	0.7257	3.9	0.999951904
0.7	0.7580	4	0.999968329
0.8	0.7881	4.1	0.999979342
0.9	0.8159	4.2	0.999986654
1	0.8413	4.3	0.999991460
1.1	0.8643	4.4	0.999994587
1.2	0.8849	4.5	0.999996602
1.3	0.9032	4.6	0.999997888
1.4	0.9192	4.7	0.999998699
1.5	0.9332	4.8	0.999999207
1.6	0.9452	4.9	0.999999521
1.7	0.9554	5	0.999999713
1.8	0.9641	5.1	0.999999830
1.9	0.9713	5.2	0.999999900
2	0.9772	5.3	0.999999942
2.1	0.9821	5.4	0.999999967
2.2	0.9861	5.5	0.999999981
2.3	0.9893	5.6	0.999999989
2.4	0.9918	5.7	0.999999994
2.5	0.9938	5.8	0.999999997
2.6	0.9953	5.9	0.999999998
2.7	0.9965	6	0.999999999
2.8	0.9974	6.1	0.999999999
2.9	0.9981	6.2	1.000000000
3	0.9987	6.3	1.000000000
3.1	0.9990	6.4	1.000000000
3.2	0.9993	6.5	1.000000000

(b) Find z from probability

prob	z	prob	z
0.5	0	0.81	0.8779
0.51	0.0251	0.82	0.9154
0.52	0.0502	0.83	0.9542
0.53	0.0753	0.84	0.9945
0.54	0.1004	0.85	1.0364
0.55	0.1257	0.86	1.0803
0.56	0.1510	0.87	1.1264
0.57	0.1764	0.88	1.1750
0.58	0.2019	0.89	1.2265
0.59	0.2275	0.9	1.2816
0.6	0.2533	0.91	1.3408
0.61	0.2793	0.92	1.4051
0.62	0.3055	0.93	1.4758
0.63	0.3319	0.94	1.5548
0.64	0.3585	0.95	1.6449
0.65	0.3853	0.96	1.7507
0.66	0.4125	0.97	1.8808
0.67	0.4399	0.98	2.0537
0.68	0.4677	0.99	2.3263
0.69	0.4959	0.995	2.5758
0.7	0.5244	0.999	3.0902
0.71	0.5534	0.9995	3.2905
0.72	0.5828	0.9999	3.7190
0.73	0.6128	0.99999	4.2649
0.74	0.6433	0.999999	4.7534
0.75	0.6745	0.9999999	5.1993
0.76	0.7063	0.99999999	5.6120
0.77	0.7388	0.999999999	5.9978
0.78	0.7722		
0.79	0.8064		
0.8	0.8416		