OMIS 2010 – Assignment B1 – Fall 2017

Assignment Instructions (please read carefully)

1. Submit your assignment to the link posted on Moodle.
2. Make sure to upload it to the correct link by section.
3. Work can be done by group of 2-3 students. Groups can **not** consist of students from other sections of the course.
4. Only one person uploads the assignment, adding all names on the file.
   The files names should be of the form: "A2_LastName1_LastName2_LastName3.xlsx"
   LastName1 is the last name of student 1, LastName2 is the last name of student 2, etc.
5. You are free to discuss your approach with other individuals or pairs, but your write-up should be prepared independently by the person(s) submitting the assignment. It is a violation of the rules of academic honesty to copy someone else's assignment and present it as your own.
6. The assignment cover page is posted (see next page).
7. You should upload the following:
   a. A completed cover page.
   b. A Word or PDF file with the assignment answers. Each answer file should include screenshots of supporting work (Excel model & output) to accompany the relevant question.
   c. Excel file with your work [always submit the Excel work to support your answer]. Use different tabs to identify the answers to each individual question when needed.
8. Generally, answers should be typed on the computer (graphs can be generated manually and incorporated into the assignment document).
9. The assignments should be organized by question. That means every piece of information for that question is found in the same section of the report. Use labeling and titles to make sure all is clear. If I have to look for it, it is not organized. Don't forget to add the Excel outputs if you used them to analyze the case. You may use an appendix to give further details of your model or calculations if required.
10. Late work will **not** be accepted. (You will earn a grade of 0.)

OMIS 2010 – Assignment Cover Page
Fall 2017

Schulich School of Business

Assignment #:	B1
Section:	

	Group Member 1	Group Member 2	Group Member 3
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Group can be minimum of 2 members and maximum of 3 members

QUESTION 1

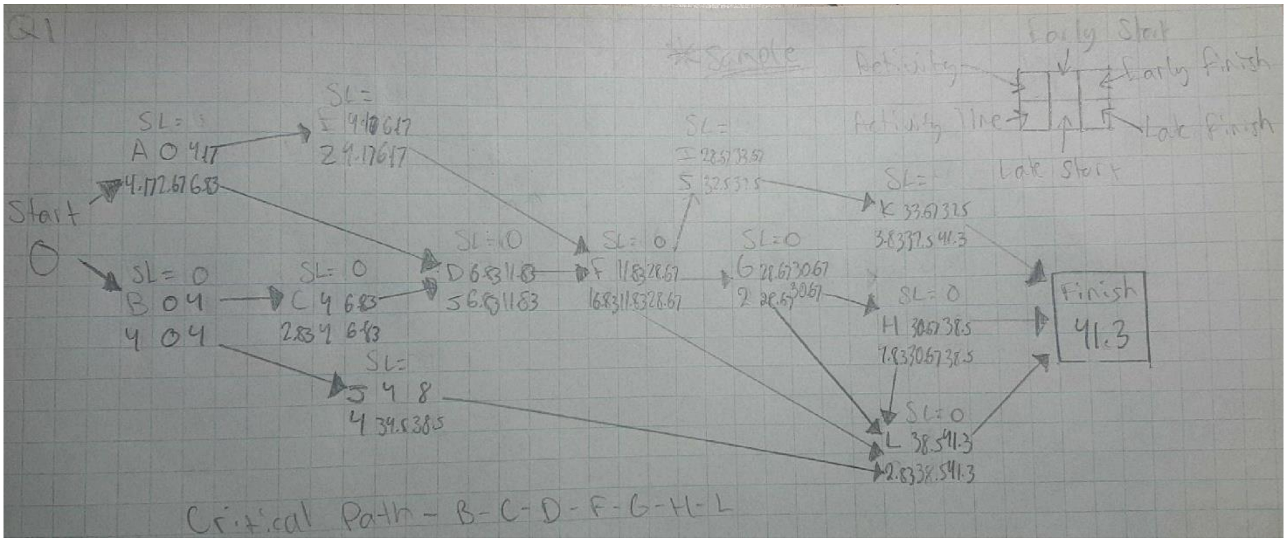
Strawberry Beach Resort is a new all-inclusive vacation resort being planned by a large hotel company on the Playa Hermosa Beach, on the western part of Costa Rica.

The senior management team has put together a small group of executives from serval functional areas to identify the major project activities, their time estimates, and interrelationships between activities necessary to successfully complete the Strawberry Beach Resort project. The result of the team work is provided in the table below:

Activity		Activity Predecessors	Time estimates (weeks)		
			Optimistic time	Most Likely time	Pessimistic time
A	Select a site	---	1	4	8
B	Select senior project staff	---	2	4	6
C	Select architect	B	2	3	3
D	Develop construction plan	A,C	3	5	7
E	Bring utilities to the site	A	1	2	3
F	Construct the buildings	D, E	12	16	25
G	Building inspection	F	1	2	3
H	Develop outdoor area and landscape	G	5	8	10
I	Finish indoor area and install necessary equipment	F,G	4	5	6
J	Select support personnel	B	3	4	5
K	Train support personnel	I	3	4	4
L	Get government approval for opening after final inspection	F,G,H,J	2	2	7

Required:

a) Draw a network to represent this case. Calculate all four times (ES, LS, EF and LF) in your network.



b) Determine which activities have slack and provide the critical path. Summarize your work in a table with the following structure:

Activity	Activity Time	ES	EF	LS	LF	Slack	Critical (Y/N)
A	4.166666667	0	4.17	2.67	6.83	2.667	N
B	4	0	4	0	4	0	Y
C	2.833333333	4	6.83	4	6.83	0	Y
D	5	6.833	11.8	6.83	11.8	0	Y
E	2	4.167	6.17	9.83	11.8	5.667	N
F	16.83333333	11.83	28.7	11.8	28.7	0	Y
G	2	28.67	30.7	28.7	30.7	0	Y
H	7.833333333	30.67	38.5	30.7	38.5	0	Y
I	5	28.67	33.7	32.5	37.5	3.833	N
J	4	4	8	34.5	38.5	30.5	N
K	3.833333333	33.67	37.5	37.5	41.3	3.833	N
L	2.833333333	38.5	41.3	38.5	41.3	0	Y

c) In your own words, define what a critical path is from a managerial perspective. What activities are on the critical path and in what order? Give an estimate of the completion time for this project.

The Critical Path is the path that will result in the shortest completion time of the project. Any delays in the critical path will result in a delay in the finishing time of the project as these activities have 0 slack; zero time idle. The Critical Path is in the following order; B → C → D → F → G → H → L.

Completion Time = $B_{AT} + C_{AT} + D_{AT} + F_{AT} + G_{AT} + H_{AT} + L_{AT}, where\ AT = Activity\ Time$

$= 4 + 2.833 + 5 + 16.833 + 2 + 7.833 + 2.833$

$= 41.33$

The estimated completion time for the project is 41.33 weeks.

d) What is the project variance? In your own words, define what the project variance means from a managerial perspective.

Activity	Optimistic Time	Most Likely Time	Pessimistic Time	Expected Time	Variance
A	1	4	8	4.166666667	1.361111111
B	2	4	6	4	0.444444444
C	2	3	3	2.833333333	0.027777778
D	3	5	7	5	0.444444444
E	1	2	3	2	0.111111111
F	12	16	25	16.83333333	4.694444444
G	1	2	3	2	0.111111111
H	5	8	10	7.833333333	0.694444444
I	4	5	6	5	0.111111111
J	3	4	5	4	0.111111111
K	3	4	4	3.833333333	0.027777778
L	2	2	7	2.833333333	0.694444444

$$\sigma^2 = B_V + C_V + D_V + F_V + G_V + H_V + L_V$$
$$= 0.4444 + 0.0278 + 0.4444 + 4.694 + 0.1111 + 0.6944 + 0.6944$$
$$= 7.1105$$
$$= 7 \text{ weeks}$$
$* \, Where\ V = Variance\ corresponding\ to\ its\ repective\ letter\ activity\ taken\ from\ the\ chart\ upon$

The Project Variance represents the expected variance for the project. It is the aggregate of all the variances for the activities that are part of the Critical Path. This can be used through statistical measures to figure out the probability of the completion of the project. This variance will be used in the following question to determine what the chance is for the project to be completed within a specific time frame.

e) Determine the probability that the project will be completed in between 43 weeks and 44 weeks?

We require the summation of the expected time values in question, and the standard deviation.

$$\mu = B_{ET} + C_{ET} + D_{ET} + F_{ET} + G_{ET} + H_{ET} + L_{ET}, where\ ET = Expected\ Time$$
$$= 4 + 2.8333 + 5 + 16.8333 + 2 + 7.8333 + 2.8333$$
$$= 41.3332$$
$$\cong 41.33$$

$\sigma = \sqrt{B_V + C_V + D_V + F_V + G_V + H_V + L_V}$
$= \sqrt{0.4444 + 0.0278 + 0.4444 + 4.6944 + 0.1111 + 0.6944 + 0.6944}$
$= \sqrt{7.1109}$
$\cong 2.67$
$*\, Where\ V = Variance\ corresponding\ to\ its\ repective\ letter\ activity\ taken\ from\ the\ chart\ upon$

We can now compute the probability in question, where $x_1 = 43$, and $x_2 = 44$

$$P(x_1 < x < x_2) = P\left(\frac{x_1 - \mu}{\sigma} < \frac{x - \mu}{\sigma} < \frac{x_2 - \mu}{\sigma}\right)$$

$$P(43 < x < 44) = P\left(\frac{43 - 41.33}{2.67} < \frac{x - \mu}{\sigma} < \frac{44 - 41.33}{2.67}\right)$$

$$= P\,(z < 1) - P(z > 0.625)$$

$$= 0.8415 - (1 - 0.7340)$$

$$= 0.5755$$

Therefore, there is a 57.55% chance that the project will be completed within 43 and 44 weeks.

f) Give a time within which the company can be 99% sure of completing the project

The variables in question are:

$\mu = 41.33$
$\sigma = \sqrt{7.1105} = 2.6666 \cong 2.67$ ←This standard deviation is derived from part e)
$z_{0.99} = 2.33$ ←This value is found through the Z-score chart

Now, we can compute the maximum amount of time it would take the company to complete the project with 99% level of confidence.

$$\mu \pm z_{\alpha/2} * \sigma = 41.33 \pm z_{0.99} * (2.67) = 41.33 \pm (2.33)(2.67)$$

$$LCL = \mu - z_{\frac{\alpha}{2}} * \sigma = 41.33 - z_{0.99} * (2.67) = 41.33 - (2.33)(2.67) = 35.1089 \cong 35$$

$$UCL = \mu + z_{\frac{\alpha}{2}} * \sigma = 41.33 + z_{0.99} * (2.67) = 41.33 + (2.33)(2.67) = 47.5511 \cong 48$$

Therefore, the time within which the company can be 99% sure of completing the project will be between 35 weeks and 48 weeks, where the minimum time it will take is 35 weeks, and the maximum time it will take is 48 weeks with a 99% confidence level.

QUESTION 2

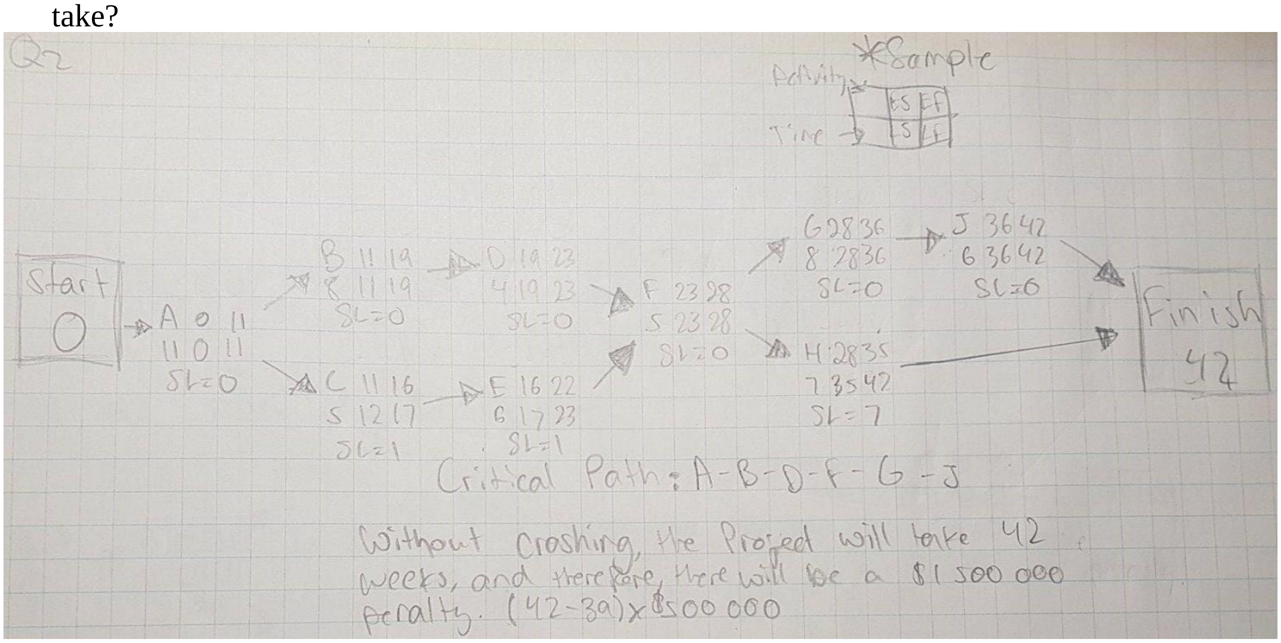
Concord Construction Management has just signed a contract with the Metrolinx to build a new maintenance facility. The pertinent data is in the table below, with all dollar values in thousands of dollars. For example, the first week of crashing Activity A is $825,000. The contract specifies a penalty of $500,000 per week for every week past 39 weeks (9 months) from today.

Activity	Precedes	Normal Duration (weeks)	Crashing Costs	
			1st Week	2nd Week
A	B, C	11	825	850
B	D	8	250	350
C	E	5	100	100
D	F	4	600	700
E	F	6	120	400
F	G, H	5	400	480
G	J	8	n.a.	n.a.
H	End	7	180	200
J	End	6	190	225

Note: The letter "I" was not used deliberately

Required:

(a) Complete the CPM diagram for this project and determine the Critical Path. Record the slack beneath each node. Without crashing, how long will the project take?



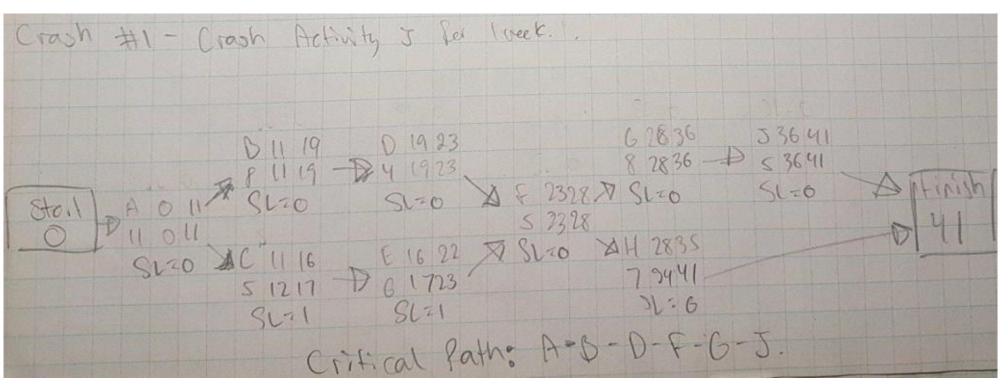
(b) Develop the minimum cost crashing program. Provide a summary table listing each crashing step (i.e. which activity was crashed and by how much) and the resulting change in cost, project duration and the critical path(s) after the crash. Summarize your conclusion
(how many days total crashed at what cost and why no further crashing was done).

	Time (weeks)			Cost ($thousands)			Crash Cost Per Week		Critical
Activity	Normal	Crash1	Crash2	Normal	Crash Week1	Crash Week2	Week 1	Week 2	Path?
A	11	10	9	0	825	850	825	850	Yes
B	8	7	6	0	250	350	250	350	Yes
C	5	4	3	0	100	100	100	100	No
D	4	3	2	0	600	700	600	700	Yes
E	6	5	4	0	120	400	120	400	No
F	5	4	3	0	400	480	400	480	Yes
G	8	7	6	0	n.a.	n.a.	n.a.	n.a.	Yes
H	7	6	5	0	180	200	180	200	No
J	6	5	4	0	190	225	190	225	Yes

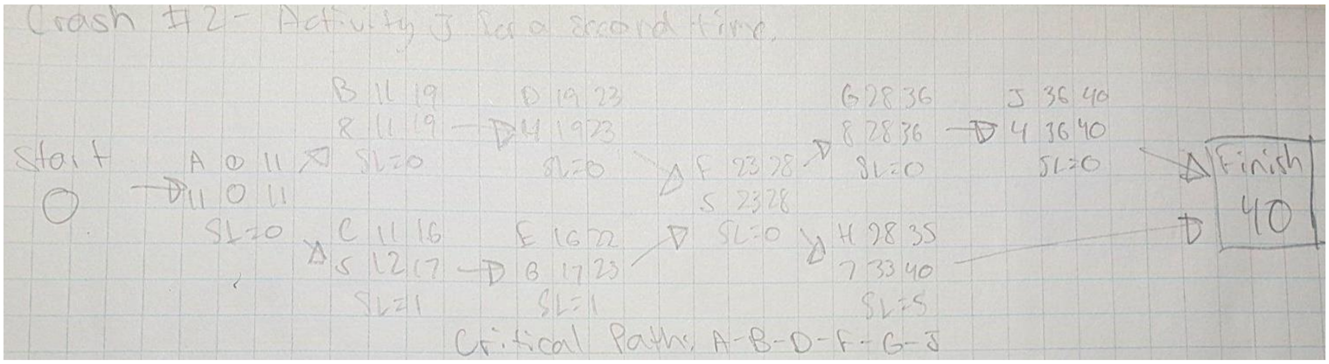
Before crashing, we must note that we exceed the maximum allotted weeks by 3 weeks, and therefore only need to crash any activity for a minimum of 3 times. Therefore, there will only be 3 crashed activities

Crashes	Penalty Amount	Cost of Crashes	Total Cost
None	3 x 500,000	0	$1,500,000
Activity J for 1 week	2 x 500,000	190,000	$1,190,000
Activity J for 2 weeks	500,000	190,000 + 225,000	$915,000
Activity J for 2 weeks and Activity B for 1 week	0	190,000 + 225,000 + 665,000	$835,000

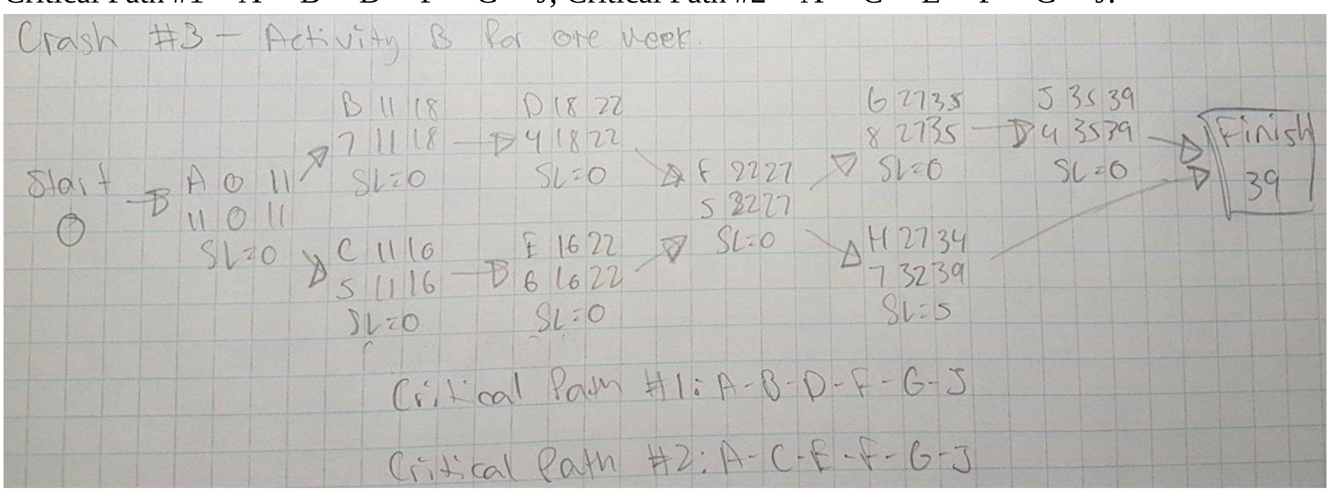
<u>Crash #1</u> – Crash Activity J for Week 1 for an added $190,000. This is because crashing for Activity J for 1 week is the cheapest alternative of all the crashes for the critical activities. This will cause the cost of the project to reduce; 190,000 + (500,000*2) = 1,190,000, which is 310,000 cheaper than without crashing any activities; 500,000 * 3 = $1,500,000. The project duration will reduce by 1 week from 42 weeks to 41 weeks, and the Critical Path will remain the same;
A → B → D → F → G → J.



Crash #2 – Crash Activity J for a Week 2 for an added $225,000. This is because crashing for Activity J continues to be the cheapest alternative for crashing. This will cause the cost of the project to reduce once again; 190,000 + 225,000 + 500,000 = 915,000, which is $585,000 cheaper than not crashing at all, and $275,000 cheaper than only crashing once. The Project duration will reduce from 41 Weeks to 40 Weeks. The Critical Path will remain the same: A → B → D → F → G → J



Crash #3 – Crash Activity B for Week 1 for an added $250,000. This is because crashing for Activity B is the next cheapest alternative of all the possible crashes. This will cause the cost of the project to reduce; 190,000 + 225,000 + 250,000 = $665,000, which is $835,000 cheaper than not crashing at all, $525,000 cheaper than crashing Activity J once, and $250,000 cheaper than if we crashed Activity J twice only. The project duration reduces to 39 weeks from 40 weeks. The Critical Path now becomes two critical paths; Critical Path #1 = A → B → D → F → G → J; Critical Path #2 = A → C → E → F → G → J.



Conclusion: There does not need to be more than 3 individual crashes, as it would be redundant; the penalty applies to weeks past 39 weeks. After crashing 3 weeks of activity, we save three weeks off the project as well as a total of $835,000.

QUESTION 3

Lark Meadow sells equestrian supplies to youth riders. Their top selling helmet – the LM500 - sells at an approximate constant rate of 50 helmets every month. Lark Meadow's current buying policy is to order 50 helmets each time an order is placed, so that only one month's worth of inventory is on hand at any time. It costs Lark Meadow $30 to place an order. The annual holding cost rate is 20%. Lark Meadow has just received a flyer from the helmet manufacturer, offering quantity discounts for purchasing larger orders:

Order Quantity	Price per pair
0 to 99	$36
100 to 199	$34
200 to 299	$32
300 or more	$30

a. Prior to receiving the flyer (assuming the regular cost is $36 per helmet) was the order policy optimal?

Q is unknown
D = 50 units per month = 50*12 = 600 units per year
S = $30 per order
H = 20% of order price = 0.2*36 = 7.2

$$Q = \sqrt{\frac{2DS}{H}} = \sqrt{\frac{(2)(600)(30)}{7.2}} = 50\sqrt{2} = 70.7106 \cong 71$$

Therefore, the order policy is not optimal. The company buys 50 units per order, whereas the Optimal order policy is at 71 units per order.

b. What is the minimum cost order quantity for the shoes?

Order Quantity	Unit Price	Order Quantity	Annual Product Cost	Annual Ordering Cost	Annual Holding Cost	Total Cost
0-99	36	71	21600	253.5211268	255.6	22109.12
100-199	34	100	20400	180	340	20920
200-299	32	200	19200	90	640	19930
300+	30	300	18000	60	900	18960
Price	Unit Holding Price	Ideal Q per Order	Mandatory Units	Feasibility	Adjusted Q per Order	
36	7.2	70.71067812	0-99	Yes	71	
34	6.8	72.76068751	100-199	No	100	
32	6.4	75	200-299	No	200	
30	6	77.45966692	300	No	300	

The Minimum Cost Order Quantity for the shoes are 300 shoes per order. This will result in the lowest annual cost; $18,960. The chart above shows the possible purchase amounts that can be made each time orders are placed, and the cheapest option on an annual basis is to buy 300 units every time orders are needed to be placed.

c. What order policy should Lark Meadow implement? How much money could Lark Meadow save by changing their ordering policy?

Currently, he is buying 50 pairs per purchase. This would equate to a total annual cost of $22,140.

TC(50) = (600*36) + ((600/50)*36) + ((500/2)*0.2*36) = 22140

The suggested order policy is that Lark Meadow purchase 300 pairs of shoes every time they are about to run out. This would save them a total of $3180; 22,140 – 18960 (figure of $18,960 is taken from the excel file above).

QUESTION 4

BoatEX sells traditional hand-made canoes. The average demand for their 3-person model is 5 units per week, with standard deviation of 1.2 units. Canoes are made by the local Chippewa nation. The Chippewa elder visits the store every 6 weeks to check the inventory level. During a particular visit the store had 13 units in stock. The lead time to receive an order is 2 weeks. The store has a goal of maintaining a 95% service level.

All order periods are assumed to be in weeks

a. What is the probability of running out of stock before the next order arrives?

We need to find P (x > 13). This is the probability that the current inventory level of 13 units will be exceeded by the average demand. If that is the case, then BoatEX will run out of stock.

Before calculating the probability, we must first find μ_L and σ_L, where μ_L equates to the weekly mean of demand during the lead time and σ_L equates to the weekly standard deviation of demand during the lead time.

$$\mu_L = \mu_d \mathrm{L} = (5) * (2) = 10$$

$$\sigma_L = \sigma_d\sqrt{L} = (1.2) * \sqrt{2} = 1.6971$$

Now, we can use these values to find P(x > 13)

$$\mathrm{P}(\mathrm{x} > 13) = \mathrm{P}\left(\frac{x-\mu}{\sigma}\right)$$

$$= P\left(\frac{13-10}{1.6971}\right)$$

$$= P(z > 1.7677)$$

$$= P(z > 1.77)$$

$= 1 - P(z > 1.77)$

$= 1 - 0.9616$

$= 0.0384$

$= \mathbf{3.84}\%$

Therefore, the probability of running out of stock before the next order arrives is 3.84%

b. How many 3-person canoes should the elder make for this order period to enable the store to maintain the desired service level?

Fill in the Data:	**Variables**	**Value**	**Units**
Average Demand Rate	d	5	Units per week
Standard deviation of demand	σ_d	1.2	Units
Review Period	P	6	weeks
Lead Time	L	2	weeks
Current Inventory	I	13	Units
Service Level	95%		$z_{0.95} = 1.645$
Exposure Period	L + P	8	weeks

$\sigma_{(L+P)} = \sigma_d\sqrt{(L+P)} = 1.2\sqrt{(2+6)} = \frac{12\sqrt{2}}{5} \cong 3.3941$

$I_{max} = (L+P) * d + z * \sigma_{(L+P)} = (2+6) * (5) + (1.645) * (3.3941) = 45.5833 \cong 46$
→ The reason we decided to round this value is so we do not arrive at a decimal value in the proceeding question. This rounding step could have been taken in the next part of the calculation, but we decided to perform it here.

$q = I_{max} - I = 46 - 13 = 33$

Therefore, the elder should make 33 units of the 3-person canoes for this order period to enable the store to maintain the desired service level of 95%