IE460 –Spring 2019
Comments on Exam I

General Comments:

Below, please find some statistics on your exam results. I would like to say that there is at least one full correct answer for each question, except Question 3, Part C. This shows that the questions are doable. Nevertheless, maximum grade is 79. Here is how I understand the outcome: If you look at each question, none was necessarily very difficult. However, I think this exam was challenging. When I was grading I felt that the combination of all four questions required you to master each topic – that was a bit demanding. I think majority of you performed reasonable.

I admit that I should be more careful with the totality of the exam. I am always a believer of “learning during the exam” idea and hence I truly think that the exam questions and the comments are instrumental for your learning.

Exam Results:

Mean:	48.00
Std. Dev.:	20.31
Max:	79
Min:	7

Frequency Distribution:

Range	0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-105
Freq.	1	4	5	2	10	4	6	7	0	0

One interesting fact is the standard deviation. It seems that the standard deviation is pretty large (when compared to the mean). Similarly, it is interesting to note that there is a local mode in the frequency distribution in 71-80 range.

One general comment on grading: I am usually very comfortable in granting a generous partial grade if I think your work shows an understanding of the material. In the contrary, if you have multiple possible answers in your exam, even if one of them is right, I usually had a tendency of not granting any partials or granting very little depending on the severity of incorrect answers.

Suggestions

I would like to reiterate that your grades are a bit below my expectations. I think that a fair average for this exam would be in the 50-55 range, but with a much smaller standard deviation value. If your grade is below 40 you should be careful in the remaining part of the semester. On the other hand, still we have another exam and other requirements; it is too early to feel confident or anxious.

Question 1

The question is about a deterministic demand, infinite horizon serial system with three stages. In class we saw how to deal with the two-stage problem. In the question, even there were three stages, two of them were told to use the same lot size, and hence the problem is, in my opinion, a straightforward extension of the one you have seen in class.

Part a) of the question asked you to write the decision variables. Almost all of you were able to respond.

Part b) of the question asked you to write inventory carrying cost. I didn’t enforce a certain approach, and allowed you to use either standard holding cost or echelon-holding cost computations. A relatively large group didn’t realize that computation of inventory carried is more complicated adding three EOQ type functions. I took 4 points off not using echelon stocks, but computing the average inventory as if each stage follows an EOQ structure.

Part c) asked you to write the average cost function. Some of you are still having problems with the notion of averages. Nevertheless, I haven't penalized you twice if you had the inventory cost incorrectly found in part b) and carried the same thing to Part c), unless of course you had a conceptual mistake in Part c).

Finally, in Part d) you are asked to give a possible algorithm to solve for n, integer multiple of the lot size. The following is what I expected, exactly the same approach we take to solve similar problem, where one variable is integer, and the other is continuous:

- Given n, solve for Q_3. Note that this means you are solving for Q_1 and Q_2, as well. Call it Q_3^*.
- Substitute Q_3^*in ATC(.) to obtain ATC(Q_3^*, n)
- Find n* by (1) enumerate ATC(Q_3^*, n) for all possible n values and select the minimum, or (2) by showing a property (such as convexity) on ATC(Q_3^*, n) with respect to n, simplify the search in (1).

The frequency distribution of grades you have received for the question are given below:

Range	**0-5**	**6-10**	**11-15**	**15-20**	**21-25**
Freq.	12	7	8	10	2

Other statistics on the results of this question are:

Mean: (out of 25)	10.95
Std. Deviation:	6.29
Max:	23
Min:	0

This question turned out to be rough one for most of you. The distribution of grades seems to be consistent with the distribution of the exam, except that we have a relatively large group (about 30%) receiving below 20% of the available grade.

Question 2

I thought this problem would be a difficult one, as it has a number of features at the same time and is not necessarily easy to understand. However, most of you did well.

In Part a) I was expecting you to formulate average profit function for the vendor. Some of you are having a problem with averaging – you can talk to us about it. There might be some ambiguity in where to place different cost/revenue components. As long as you were consistent and didn't make a mistake in the obvious terms, I took it acceptable. The following paragraph summarizes cost/revenue terms:

- Vendor: Revenue per unit – P; hence annual revenue is PD. Note that this is not constant as P is a decision variable.
- Vendor: Revenue per order received – S_O per order received. Hence, N is number of orders and $N=D/Q$. So annual revenue of orders received is $S_O\, D/Q$ or substituting D/Q *by* α/P we obtain the annual revenue from this component as $S_O\, \alpha/P$.
- Vendor: Fixed cost of manufacturing per order – S_F. : Average cost per year is $S_F\, \alpha/P$.
- Vendor: Unit cost of manufacturing is C and hence annual cost of variable manufacturing cost is CD, a constant.
- Vendor: Inventory carrying cost is paid by the vendor. Average inventory is $Q/2$ and hence average cost is $CHQ/2$ or $CHP/2\alpha$.
- Total Annual Profit – $G(P) = PD + S_O\, \alpha/P - S_F\, \alpha/P - CHP/2\alpha - CD$.

For Part b), I wasn't expecting you to conduct full analysis to obtain the results. Further, I thought that I would do it in the comments. What I expected from you was as follows: You take the derivative of the G(P) function and proceed. If you did so, you received full grade unless you made a logical mistake, given your classification of costs. However, it would be interesting to see how parameter values affect the problem:

- If S_O is greater than S_F it becomes a source of revenue for the vendor (manufacturer). Additionally, it means that the vendor is making a positive income with every order and hence wants to increase the number of orders. Also if the number of orders increase the inventory carrying cost will go down, and revenue received will be up as long as $PD- CHP/2\alpha$ is positive. As a result P will have a tendency of going to infinity, unless restricted.
- Negative revenue: If S_O is not greater than S_F and if $PD- CHP/2\alpha$ is negative, there is no change for the vendor to make a profit. So this means that α can not take an arbitrary value, but should ensure a positive. However, there is an optimal solution for P which will maximize the average profit (though average profit will be negative).
- So we have two possible cases left: (I) S_O is greater than S_F and $PD- CHP/2\alpha$ is negative. The solution that satisfies the first order condition is a minimizing point. Hence the revenue maximizing solution for P can be found in the boundaries. In this case P would attain a value close to zero, increasing indefinitely the revenue coming from orders.(II) The remaining case is similar to the first one above: As a result P will have a tendency of going to infinity, unless restricted.

Here are a few features of the problem which I thought would be interesting to convey:

- There is usually more than one way of understanding a certain problem; even if it is a prepared question for the exam. Think about what the extent of misunderstanding when a real life problem is there with plenty of vague statements! Hence, I decided that I will not take points off (of course unless you were inconsistent, or incorrect in some other aspect) if you have misplaced some of the cost/revenue terms.
- There are possible ways of approaching the problem: You can write the average profit function in terms of price, or in terms of quantity. As long as you can observe their relations (quantity with price, number of orders with quantity) and not treat them as if they are independent during optimization, you are doing ok.
- When I asked the second part of the question; one should have a thorough analysis of the optimal solution. I was aware that it was too much to ask for. So, I gave full grades if you simply attacked the problem as an optimization problem and solved the first order conditions. However, some grades were taken off if you have not realized that the term you wrote in the square root is negative!
- As a result of analysis, two possible supply chain profit division of the simple contracting situation described in the problem can happen: Either the manufacturer (vendor) will get all the income (as price goes to infinity or as the price goes to zero) and the retailer will, as a result will be in heavy loss or the optimization will result in a price value, a solution where the manufacturer is in loss. Hence, the solutions obtained are not sustainable. This is frequently encountered in real life situations as well resulting in some additional subsidies or financial support that comes in different ways. I can conclude that unless serious though is given to such contracting situations, it is not straightforward to come up with one which is fair.

The frequency distribution of grades you have received for the question are given below:

Range	**0-5**	**6-10**	**11-15**	**15-20**	**21-25**	**25-30**
Freq.	4	6	6	9	4	10

Other statistics on the results of this question are:

Mean: (out of 30) 17.36
Standard Deviation: 9.50
Max: 30
Min: 0

This is the question where you were the best as a class. However, I want you to go over the above comments carefully – it shows that sometimes you will need to go for further analysis.

Question 3

This is a standard question, though I understand that Part A was too tedious for solution.

Here is a sketch of the solution:

Part A.

i) Formula was available.

ii) Formula was not directly available but you need to use a combination or solve from scratch.

iii) Formula was available. Some of you didn't realize that I was asking the maximum expected supply chain profit, and hence substituted Q in the expected profit function they wrote and tried to evaluate that.

iv) Formula was available. Note that regardless of Q you select, the expected number of equipment sold plus the expected number of unsatisfied demand should be equal to the expected demand (i.e. (ii) + (iv) = expected demand).

Part B.

i) Formula was not available directly. That was probably the reason for the low success percentage of this part. However, once % profit going to the retailer is given, you can write one equation from this information. The other information is the knowledge that optimal Q should be the same and the optimality conditions for Q being the same for retailer and supply chain.

ii) This might come a bit unusual, but what we have in (i) above is a system with three parameters- % of channel profits going to retailer, w and b. In this part I gave w and asked for the remaining two. The equations utilized for (i) are still to be used.

Part C.

Formula was not available directly. That was probably the reason for the low success percentage of this part. However, once % profit going to the retailer is given, you only need to write one equation regarding the Q values being equal.

Regarding the grading scheme used: I tried to be as flexible as possible in rewarding partials. Nevertheless this is the question where some of you wrote answers which don't make much sense. One common mistake was to try to compute the expected profit using cost of underage and overage terms. You can of course do it that way (with correct usage of "costs"9, however you have to be careful and convert the obtained quantity to expected profit terms. Second relatively common mistake was to replace an expectation of a function of a random variable with the function evaluated at the expected value of the random variable. This is a serious mistake.

The frequency distribution of grades you have received for the question are given below:

Range	**0-5**	**6-10**	**11-15**	**15-20**	**21-25**
Freq.	18	9	10	2	0

Other statistics on the results of this question are:

Mean: (out of 25)	7.33
Standard Deviation:	4.93
Max:	19
Min:	0

This question turned out to be the nightmare for almost all of you. I accept that Part A was too long, and hence you were probably psychologically tired at the end, and could not deal with Part C. Almost half of you receiving below 20% of the available grade, on the other hand, is not reasonable for a topic for which I spent about four lecture hours..

Question 4

This is a rather standard safety-stock inventory problem encountered in real life. I would informally name it as the ABC of inventory planning. The logic behind it simple: Unless you have a specific reason, you have to use a method to assign safety stocks which are consistent in terms of a given service notion. This doesn't require the analyst to estimate any backorder related cost or any specific service level value, but encourages the analyst to understand the implications of different selections.

Part a) considers "days-of-supply" to represent SS in terms of demand. This is meaningful, as one would need to represent SS in terms of future demand values (which might not be necessarily constant). However, following this one should not fall in the trap of simplicity and take the same "days-of-supply" for all products. The total value of SS for two items turned out to be $275.

Part b) asked you to write the implied CSL for both products using table of values supplied.

Part c) turned out to be difficult for most of you. Once you write

SS = k standard deviation over (lead-time + review time),

it asked for a common k value that will yield the same total cost as Part a). In other words,

$275 = k (c_1 \sigma_1 + c_2 \sigma_2)$, where σ_1 and σ_2 are the appropriate standard deviation terms over (lead-time + review time) for item 1 and item 2, respectively.

Part d) exemplifies a sample computation to understand the implications of service level change on expected costs.

Common mistake: Some of you didn't take (lead-time + review time) standard deviation correctly. Note that they were directly given, ad you didn't require any additional computations!

Additionally, a group of you didn't attempt to solve this problem or attempted in a way which doesn't seem to be relevant to he problem statement.

The frequency distribution of grades you have received for the question are given below:

Range	**0-5**	**6-10**	**11-15**	**15-20**	**21-25**
Freq.	15	0	7	7	10

Other statistics on the results of this question are:

Mean: (out of 20)	12.36
Standard Deviation:	9.77
Max:	25
Min:	0

My experince is usually to have such a distribution for the questions I ask: A mode in the lowest 20% and another mode in the highest 20%. Of course, standard deviation is high, simply showing that some of you, for one reason or another, study only some of the topics. However, when you look at the total, the students in the lowest 20% are not necessarily the same for different questions.