IE375 –Fall 2020
Comments on Exam I

General Comments:

I think that this exam is a reasonably standard one aiming at evaluating your related knowledge, as well as your performance on the basics of the course. This exam required you to analyze numbers, as well as to conceptually approach to some cases. Engineers work on data, and hence you need to accumulate an experience to understand, interpret, and utilize "numbers" obtained. The first question is on forecasting that brings most of what you have covered in class. The question was straightforward for those of you who followed the class and complemented with the textbook. The second question is on tracking the quality of a forecast – essential material you need to know to implement forecasting. Questions 2, 3 and 4 relied on your knowledge of planning (the essence of what we have covered for Aggregate Production Planning and Inventory), and part of it relies on your modeling knowledge of IE202, as well as optimality and duality ideas.

This exam is a balanced one requiring you to apply modeling or methodologies (Question 1 and partly Question 4), to model or interpret a given model in a different form (Question 2, partly Question 3, partly Question 4), and finally to use your judgment in Question 3 and partly Question 4, although many of the above requires you to use your judgement anyway.

I am not especially unhappy with the results, in general. I believe the exam was not difficult in general and I would think that the average should be around 60 (which turned out to be close to the average), taking into account the fact that some of you have the habit of skipping a whole topic and not answer the question at all. One thing that I noticed, although less in number, you have a tendency of writing several answers, rather than one – my partial granting scheme did not allow those situations. You were held responsible for everything you have written. If there was something which did not make a sense, you lost points.

One observation regarding optimization ideas: Question 3, I believe, showed that some of you lack key ideas of optimization: Meaning of optimization, optimal value versus constraint set, and finally duality ideas. You may want to refresh these ASAP, as these are your main assets as IE, compared to other engineers.

Another observation is regarding your LP modeling skills. I believe that some of you need to go over the standard material before the final exam. Abstraction, and as a special case formulating LP's should be your least admissible advantage over the other fields – and avoiding knowing it (or not knowing it) is not acceptable.

One crucial observation: You need to read the questions carefully. For one reason or another (test habits), some of you still tend to skip parts of the problem information stated in the beginning. Next time, please be more careful on to read and answer all the questions.

One final observation is about the way that you round numbers. You must make sure that you treat all the values in the required accuracy. You lost some points when you rounded too much. Of course, there is always a limit on the number of digits to carry, and that understanding should come with the problem statement.

Below, please find some statistics on your exam results. We would like to say that there is at least one full correct answer for each part of any question. This shows that the questions are doable.

Mean: 58.76
Std. Dev.: 16.14
Max: 86
Min: 25

Frequency Distribution:

Range	**0-10**	**11-20**	**21-30**	**31-40**	**41-50**	**51-60**	**61-70**	**71-80**	**81-90**	**91-100**
#	0	0	4	2	4	6	13	6	3	0

Suggestions

Note that the mode of the grades is in the range 61-70 (also almost 65% of the grades are in the range 51-80). The grades look symmetric with a bias towards lower grades (meaning that there are more grades in the lower part). I believe this is an indication of a fair exam, at the same time tells us about the existence of tough questions which were solved only by a few students.

If your grade is below 50 you should show much more effort in the forthcoming exam and assignments. On the other hand, still we have time in the course; it is too early to feel confident, or to feel anxious.

One comment is presented below to improve your exam effectiveness:

- A particularly important issue in this course should be formalism in expressions. I think that one of the most important assets you are going to have as engineers is your ability to structure and be able to express complicated problems. To express a difficult decision structure by use of a mathematical program, or a simulation model (computer program) or even with some inequalities are examples of an IE's contribution to hard problems. Similarly, your ability to formally express complicated structures makes you different from an ordinary, a knowledgeable smart person, as with your equipment you can attack much harder problems. I want you to be careful with respect to this type of formalism in this course. Note that because of the idea of formalism, what you are expected to do can be summarized as follows:
  - ✓ When a question is posed, express the question in mathematical (symbolic) terms. Note that you have to give definitions in case you are using parameters to specify quantities and of course decision variables (almost always this is the case! – if you are not sure what a parameter or a decision variable means LEARN). Note that you would get a considerable % of the total available grade in this exam if you have defined the decision variables used.
  - ✓ Never start writing up a bunch of numbers without stating what you are doing. It is likely that you are going to have a mistake in writing those specific numbers, and hence it is always meaningful to specify abstractly the quantities you want to write (example: using a summation term, identifying an index properly, etc.).

Question 1

This is a rather standard forecasting question, asked in a structural way. Note that if I ask an arbitrary forecasting question, to show the results in a similar tabular format will be neat.

Part a): Most of you started by finding smoothing constants. Most of you were able to find them correctly. I accepted some of the computational errors – acceptable to a certain extent. However, if you obtained a smoothing constant value close to 1 (or in a few cases larger than one or less than zero) and if you haven't suspected from your computations, less partial (even no partial) grade was granted. Remaining part of the question required you to use the correct model (model with trend only) for your computations. No partials were granted if you used a wrong formula, indicating an incorrect model. Your effort to obtain each value asked was given equal points. One remark on the computation of e (error term) using just MAD information: It is not possible to do it as you can only obtain absolute value of the error.

Part b) required you to forecast the items for Period 9 given the information of demand realized in Period 8. Unless you used the correct model, you were not granted any partial grades.

Part c) asked you to forecast far in the future and for the sum of four periods. The answer should not be any different than for part b); however, some of you changed the model used and gave mostly incorrect answers (though some corrected their mistakes in Part b!). If you did not compute the sum you were taken off one point, just to check whether you are reading the question carefully. Among those who responded this part of the question (correctly or incorrectly), one third of them did not take the sum.
Forecasting implementation is a simple process which requires use of equations in a certain order, first to update and then to forecast. Simple Excel type implementation is useful and most of the time sufficient.

Your performance varied a lot in this question. A group of you were able to have full grades or almost full grades. The most frequently encountered mistake is not to use the correct model consistently throughout the parts. Formulas were supplied, but you need to know which ones to apply – it means you need to understand the models. If you used an incorrect model to estimate one of the parameters, you have not received any partial grade (for the part of the grade that is allocated to that parameter). Even if you used correct model, you made some computational errors which I find inevitable during short time periods like exams. No penalty was given for "small" computational errors, in general. However, if you have encountered an unreasonable numerical outcome, you should be able to observe it and correct it, even during an exam.

I did not penalize some immaterial computational errors but took some points off if they were far away from the correct value (and mostly a mistake that should be observed). In general, for such questions I would recommend you use the earliest data to estimate, for example α and β, so that accumulated round-off errors would be the least.

For Part b) and Part c) if you used an incorrect model for computations no partial grades were granted. On the other hand, if you made some computational errors which may affect the outcome of the questions, if you were consistent no grades were taken off.

One final remark: A small number of answers for Part c) contained explanations like "we cannot forecast for the demand of Period 12, as the most recent information is given for Period 8". These are not reasonable, as you always forecast under available information – of course, the further in time you try to forecast, the lesser accuracy it will have.

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

Range	**0-10**	**11-15**	**16-20**	**21-25**	**26-30**	**31-35**
# of students	1	3	8	7	6	13

Other statistics on the results of this question are:

Mean: (out of 35) 25.4
Std. Deviation: 7.52
Max: 35
Min: 10

Now, probably you can analyze the above information, as well. If the grade you received is 20 or below, I suggest you start forecasting chapter from scratch.

Question 2

The question is prepared to test your understanding and ability to model different situations arising in production planning as a mathematical program. IN my opinion, class performance in this question in absolute terms was poor.

While it has been argued by many that modeling involves art more than science (and thus cannot be learned), we believe that many problems in specific areas, particularly production planning problems have common features and one can get pretty good at modeling by solving problems and carefully reviewing existing models. Following should help for the specific question and production planning models in general.

- Use separate variables (and separate constraints) whenever necessary for different products and locations. In this example, we need separate inventory balance constraints for yarn and fabric.
- An inventory balance equation should include everything that goes in and out of the inventory type. While most of you incorporated the transfers in or out of an inventory type in your inventory balance

equations, only a few people included the use of fabric production for the yarn inventory – the demand for yarn is actually the production of the fabric.

- Inventory balance equations are sufficient to make sure that the demands are satisfied (or backordered and carried over to the next period). Some of you are writing additional constraints for this purpose. These are simply not necessary, and some variants of these additional constraints may even lead to feasibility problems in the model, meaning that they restrict the optimality.
- You need to associate all workforce levels (or any other resource capacities) with production quantities.
- Do not forget to write down the initial values of the inventory and workforce levels. The variables should also be designated non-negative when necessary.

Part A: Simple, most of you have done it. Some: Learn the difference between a parameter and a decision variable!

Part B: See the above comments. I think your performance was not good, as some of you missed the basics.

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

Range	**0-5**	**6-10**	**11-15**	**16-20**
# of students	**5**	**7**	**20**	**6**

Other statistics on the results of this question are:

Mean: (out of 20)	11.68
Standard Deviation:	4.42
Max:	19
Min:	0

One final comment: What will make you different (as an IE) from all other disciplines is your ability to model and interpret such models. In that respect, your performance in this question should have been much better than the other questions in the exam.

Question 3

This is very standard question, especially the first two parts. If you are a person who can relate questions, the answer for some part of a) was available in Question 2. Part b) is the extension of I variables to receive negative values. You use a standard modeling trick to handle this situation: Redefine I_t as difference between $I_t = I_t^+ - I_t^-$, where the + part is inventory and – part denoted backorders. The rest is straightforward.

Part c) is quite simple, if you understand what feasible region, optimal, dual variables, etc. I do not want to restate (and very unhappy to emphasize) the importance of these topics (together with modeling) for somebody who is studying in his/her junior year at an IE department. I do not think that you deserve to be called an IE if you do not know these topics. Here are my summaries; if you do not understand these you need to catch up:

- If you have a larger feasible set, everything else kept constant, your optimal objective function is never worse (adding the possibility of backorders to the problem enlarges the feasible set, regardless of its cost. If the costs are appropriate, you will find a better solution - less cost or more profit depending on the objective function. If not, the solution which does not use the additional flexibility brought will be optimal, meaning that in the worst case, the optimal will be the same as before.
- Part i) and Part ii) were similar, in this respect.
- If a dual variable associated with an inequality constraint is positive, it means that the slack associated with the constraint is zero, i.e. the constraint is binding. Relaxing this constraint will make the OF better (meaning that if it is cost, less cost; if it is profit, more profit).

The way that I graded the answers followed the following two rules: (1) If you did not notice the effect correctly you were not granted any partials. (2) In the rest of the cases, I granted some partials if you did not have any contradictions in your answer.

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

Range	0-5	6-10	11-15	16-20	21-25
# of students	6	9	11	10	2

The results are disappointing, as most of you did not do well in part c).

Other statistics on the results of this question are:

Mean: (out of 25) 12.34
Standard Deviation: 5.77
Max: 25
Min: 1

Question 4

The question is prepared to test your understanding and ability to model different situations arising in inventory planning. You are given a two-situation case and asked to answer the question without solving. Note the General Comments above; most are relevant for this question. The performance in this question in absolute terms was poor.

Part a) Asks you to describe what you will do. There are two possibilities, hence you are expected to solve both, and compare. Note that one requires you to do in-house production and EOQ formula should be utilized, whereas the other asks you to apply again the EOQ formula for outsourcing. However, while comparing at the end you need to include the effect of unit acquisition cots as they are different.

Part b) asks you to find the value of A, fixed ordering cost to outsource, that will make the decision indifferent. This means that you are looking for the A value for which both costs will be equal, of course including the unit acquisition costs as they are different. This is a very realistic problem, as you usually would not know the fixed cost ahead of time. The fixed cost may include transportation costs to be paid, and hence the A value you find becomes more important in deciding how to perform the transportation of the items. The solution is simple: You write the cost functions which resulted from optimization and equate.

Common mistakes made are as follows:

- ✓ To my surprise, only 5-6 students considered the differences in the unit costs as relevant. If you did not take this difference while comparing in part a) or finding the threshold value in part b) you lost 6 points (3+3) in total. This is the reason why the highest grade was 14 out of 20 in this question. Note that those who took the unit cost difference into account were not able to use EOQ for the solution of the problem.
- ✓ Use of correct holding cost figure. Note that holding cost per unit is a function of the unit cost.
- ✓ No EPQ formula for in-house production as was not given in the problem statement. Of course, you can say that "I assume … " and solve, but it is meaningless to take it for granted.
- ✓ Use of incorrect fixed ordering cost in case of outsourcing; in other words, not using K (unknown).

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

Range	0-5	6-10	11-15	16-20
# of students	10	5	23	0

Other statistics on the results of this question are:

Mean: (out of 20) 9.34
Standard Deviation: 4.78
Max: 14
Min: 0