University of Alberta, Alberta School of Business
Department of Accounting and Business Analytics

OM 352, LEC A1, Fall 2023 **Final Exam** **12 December 2023**

Instructor: Saied Samiedaluie

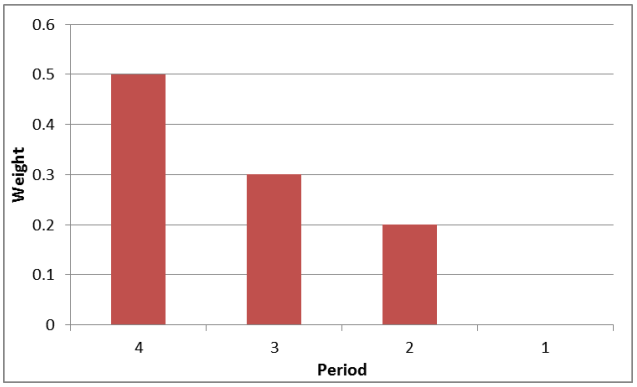
Instructions

1. You have 3 hours for the exam. A proctor will tell you when you can start. Start times may differ by up to 10 minutes between the labs (that is, your lab's start time could be anywhere from 9:00 AM to 9:10 AM). The end time will be 3 hours after the start time, for every lab.
2. You must not communicate with anyone in any way about this exam between 9 AM−5 PM on Tuesday, 12 December 2023 (Edmonton time).
3. You will use the Online Assessment tool to access the exam and to submit your answers. We recommend that you submit every 15 minutes. Your last submission will be used for marking.
4. You may use any books, notes, tables, formula sheets, and computer files that you wish.
5. You may access any web pages you wish during the exam, as long those web pages do not allow communication between you and others. You may not use email, chat rooms, or any other Internet-enabled communication during the exam.
6. You can read messages in the OM 352 discussion forums, but you cannot post new messages.
7. If the computers in your lab have dual monitors, then you can only use one of the monitors.
8. To ensure that all students have only a single monitor, you may not use a laptop.
9. Enable macros right after opening the Excel (XLSM) file.
10. Turn phones, pagers, and all other communication devices off before the exam and leave them off and out of sight until after you leave the lab.
11. Submit your exam on time. The penalty for late submission is 0.25% per second (= 15% per minute).
12. Ask a proctor for help immediately if you experience any technical problems.
13. The point breakdown is as follows:

Topic	Points	%
Forecasting	15	22%
Monte Carlo Simulation	9	13%
Aggregate Planning	15	22%
Distribution Planning	7	10%
Predictive Analytics	8	12%
Inventory Management	7	10%
Congestion Management	7	10%
Total:	**68**	**100%**

Do <u>not</u> return this printout at the end of the exam. All of your answers must be in the "Answers" worksheet of the Excel file.

Forecasting (15 pts.)



1. (1 pt.) If the weights shown above are used to calculate a forecast for period 5, which method is this?

a) Last point method
b) SMA with window size of 3
c) WMA with window size of 3
d) SES with LS = 0.5

2. (1 pt.) If MAD of a forecasting method is zero, which of the following is guaranteed to be true?

a) RMSE = 0
b) BIAS > 0
c) TES has been used
d) Solver was used to minimize MAD

3. (1 pt.) Which of the following statements is wrong about the double exponential smoothing (DES) method?

a) DES captures level and trend
b) The out-of-sample performance of DES is not necessarily worse than that of the TES method
c) The DES forecast for period *t* cannot be smaller than the smallest data point observed before period *t*

Number of potholes filled by the city (12 pts.)

The FC1 worksheet shows the number of potholes in roads that were filled in the City of Edmonton from January 2012 to August 2020.

4. (1 pt.) What is the average number of potholes filled by the city in December?

5. (2 pts.) Calculate and report the SMA forecasts with window size of 6 for January 2020 to August 2020.

6. (6 pts.) The FC2 worksheet has the same data as FC1 and a partially completed model for the TES method with an annual seasonality pattern and the year 2020 data as a holdout data. Complete the TES model and report the following values. Do not change the values for LS, TS or SS.

- Values of level and trend for December 2019
- Seasonality indices for every month in 2019
- TES forecasts for January 2020 to August 2020
- Out-of-sample BIAS

7. (1 pt. feasibility, 1 pt. consistency, 1 pt. optimality) The FC3 worksheet has the same data as FC1 and a completed model for the WMA method with window size of 3. Use solver to find the best values for w_1, w_2, and w_3 so as to minimize the RMSE for year 2020. The sum of weights should be equal to one and the weights should not increase for older data, which means $w_1 \leq w_2 \leq w_3$.

Monte Carlo Simulation (9 pts.)

8. (1 pt.) What is the most likely result returned by IF(RAND() – RAND() >= 0.22, "Pass", "Fail")?

a) Pass
b) Fail
c) Pass and Fail are equally likely

Simulating demand (4 pts.)

The MC1 worksheet has a partially completed Monte Carlo simulation model. Demand in January is normally distributed with mean = 200 and standard deviation = 15. Demand in February is normally distributed with mean = 195 and standard deviation = 25, and independent of demand in January. We would like to estimate the probability that demand in January is larger than demand in February. Use 20 replications.

The RAND() values are in the MC1 worksheet. All formulas in the MC1 worksheet are correct. The first two steps in building the model have been completed. All that is left is to create the data table to collect the simulation outputs for all replications.

9. (2 pts.) Report the January demand and the February demand for Replication 17.

10. (2 pts.) Report the proportion of the 20 replications in which the January demand is larger than the February demand.

Car ownership cost (4 pts.)

You recently inherited a 1990 Mustang GT. The car is still drivable but it costs you a significant amount of money in maintenance and repair. The remaining lifetime of the car follows an exponential distribution with a mean of 10 years. You do not plan to keep the car beyond 10 years. So the number of years you own the car will be = MIN (remaining lifetime, 10).

The MC2 worksheets has random numbers for 10 replications and a partially complete simulation model. The average cost of owning the car per year is $1,250. You want to estimate the cost of owning the car from now until it stops working or 10 years from now, whichever comes first.

11. (2 pts.) For replications 5 and 6, report the simulated remaining lifetime of the car.

12. (2 pts.) For replications 5 and 6, report the simulated total ownership cost of the car.

Hint: You have learned how to simulate from an exponential distribution in the Congestion Management topic.

Note: It is a good idea to freeze your data tables after you are done with this section.

Aggregate Planning (15 pts.)

13. (1 pt.) Solver displays the message "Solver found an integer solution within tolerance. All constraints are satisfied." What does this mean?

a) You have too many constraints
b) You have too few constraints
c) You have found the optimal solution
d) You did not set Integer Optimality (%) to 0

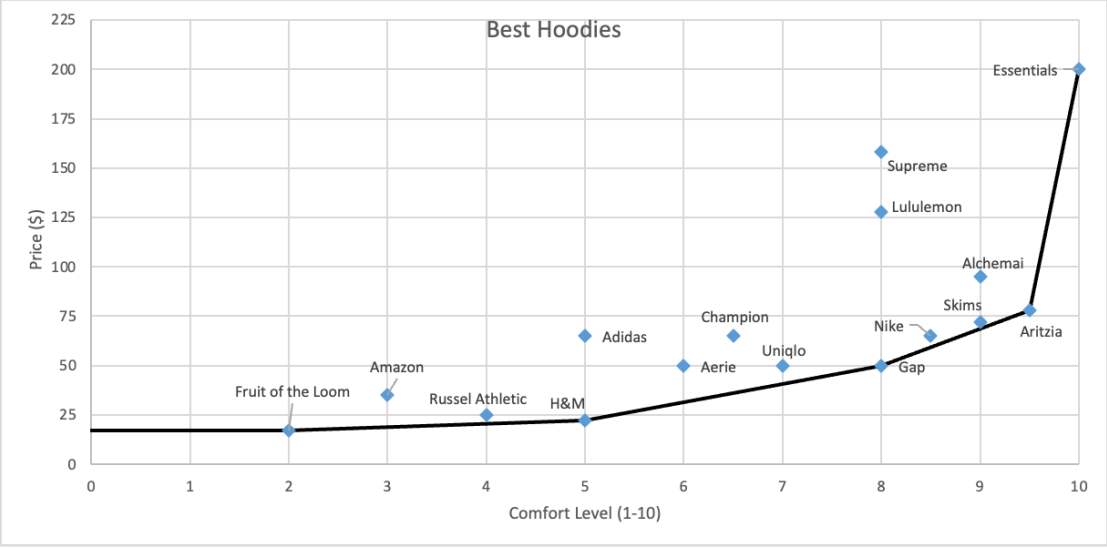
14. (1 pt.) Which of the following is true regarding integer constraints in linear optimization problems?

a) Integer constraints prevent solver from generating a sensitivity report
b) Problems with integer constraints are in general easier to solve
c) Adding integer constraints to a profit-maximization problem can lead to higher profit
d) If we do not include integer constraints in solver, it is impossible to get an integer optimal solution

15. (1 pt.) In a cost minimization model, removing a constraint will cause the minimum total cost to:

a) Stay the same or increase
b) Increase
c) Decrease
d) Stay the same or decrease

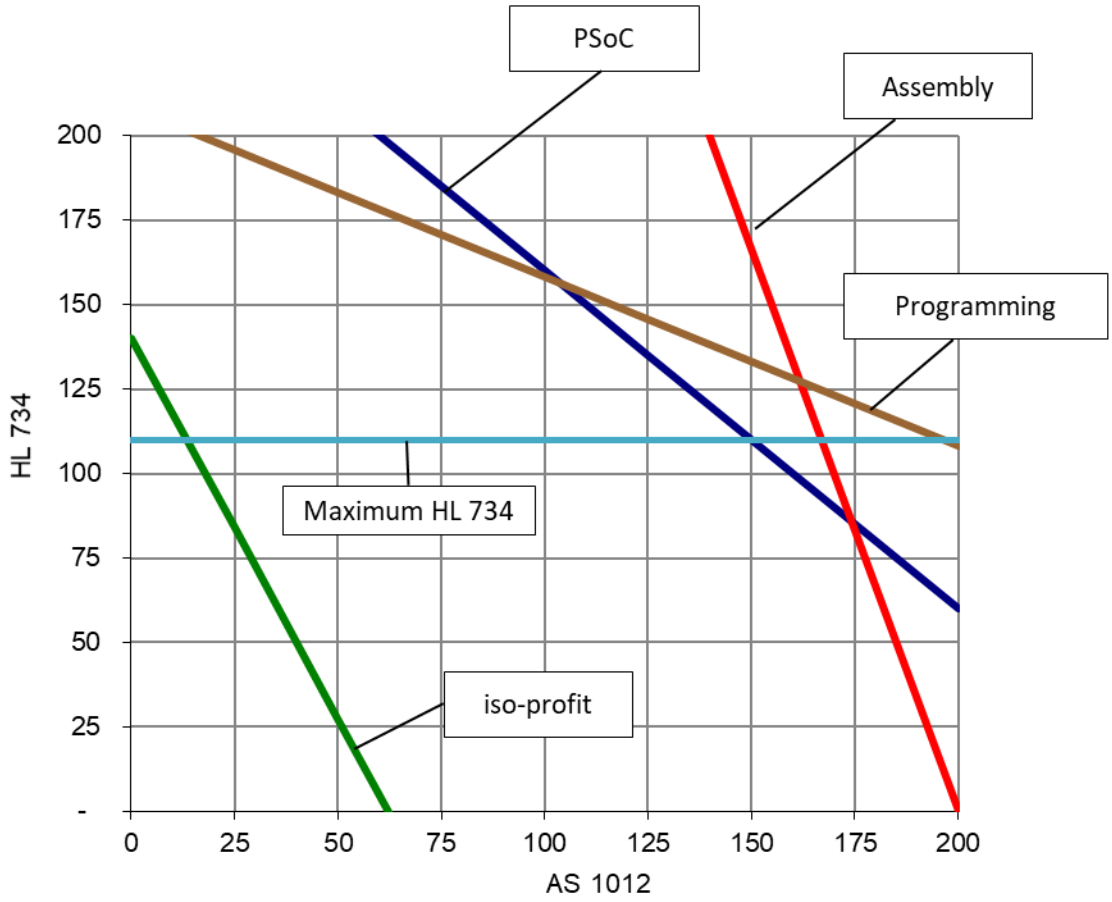
A sample of 100 university students voted on the best hoodies based on comfort level (rated 1-10, 10 being the most comfortable hoodie) and price.



16. (1 pt.) Which of the following is FALSE based on the efficient frontier above?

a) Aritzia dominates Alchemai
b) Nike dominates Supreme
c) Champion is dominated by Uniqlo
d) Lululemon dominates Aerie

Graphical Analysis: The graph below shows the constraints and an iso-profit line for a modified version of the Leduc Control example. The constraint that has been added is that we have to produce at most 110 units of HL 734. Answer Questions 17-18 based on this graph.



17. (1 pt.) Which of the following is a feasible solution?

a) (25, 125)
b) (200, 0)
c) (150, 125)
d) (175, 175)

18. (1 pt.) What is the optimal solution? (x, y) = (numbers to make AS 1012, numbers to make HL 734)

a) (0, 100)
b) (104, 154)
c) (150, 110)
d) (175, 85)

Below is the sensitivity report of the WestPlast example, in which we maximize the total revenue with subject to demand/contract constraints, a capacity constraint, and a minimum total PCI index constraint. Answer Questions 19-20 based on this sensitivity report.

Variable Cells

Cell	Name	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
H3	E: Canada	30	35.50434783	100	1E+30	35.50434783
H4	B: Altoil	16	10.0826087	81.1	1E+30	10.0826087
H5	C: Canada	30	7.913043478	69.8	1E+30	7.913043478
H6	A1: Colpop	135	22.36956522	67.3	1E+30	22.36956522
H7	C: Export	66.08695652	0	65.8	8.588888889	4.815
H8	A2: Canada	30	16.66956522	61.6	1E+30	16.66956522
H9	F2: Calcan	0	-4.186956522	57.7	4.186956522	1E+30
H10	D: Local	0	-4.486956522	57.4	4.486956522	1E+30
H11	A2: Export	20	6.669565217	51.6	1E+30	6.669565217
H12	F1: Canada	7.913043478	0	35.8	9.5875	32.1

Constraints

Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
H14	Total PCI: Plan	23968	-1.304347826	23968	968	90
H15	Capacity used: Plar	335	146.6695652	335	1.058823529	15.61290323

19. (1 pt.) Will the optimal solution change if the revenue for Pellet A2: Canada decreases by $15?

a) Yes, the optimal solution will change to produce less of Pellet A2: Canada
b) No, the optimal solution will not change
c) Yes, the optimal solution will change to produce more of Pellet A2: Canada
d) We cannot answer this question based on the sensitivity report

20. (1 pt.) How much does the total revenue change if we increase the minimum PCI index requirement by 100 units?

a) The total revenue decreases by $130.43
b) The total revenue increases by $130.43
c) The total revenue does not change
d) We cannot answer this question based on the sensitivity report

Production Planning at Lululemon (7 pts.)

Lululemon produces a variety of products (T-shirts, leggings, tank tops, joggers, etc.) using Nulu fabric, which is made by an external supplier. However, recently Lululemon has been considering producing the fabric themselves, rather than using an external supplier.

Lululemon has a selection of 5 production plants, each with their own variable and fixed costs. Lululemon has an overall minimum production demand of 315 (in thousands). If opened, each plant location has also a minimum production quantity. Further, Lululemon does not want to open more than 3 locations.

The AP worksheet contains a partially completed model.

21. (4 pts. for feasibility, 2 pts. for consistency, 1 pt. for optimality) Find the production plan that minimizes total costs (the sum of fixed and variable costs) and satisfies all constraints. Report the amount to produce at each location, whether to open each location, as well as the total fixed costs and the total variable costs.

Distribution Planning (7 pts.)

Taylor Swift's Concert in Edmonton (7 pts.)

Taylor Swift is considering bringing "The Eras Tour" to Edmonton but is concerned about how long it will take for fans to get to their seats. Commonwealth Stadium is notorious for taking fans a long time to get from the transit station to their seats. You have been asked to provide a plan on how to get fans from the transit center to their seats, minimizing the total time the gates must be open.

The DP worksheet provides a diagram of the stadium configuration with the green nodes (1 and 2) being the transit centers, orange nodes (3-8) being stadium gates, and blue nodes (9-16) being seating sections. Arcs from the transit centers are one-way arcs, and the remaining arcs are two-way arcs. All arcs are provided in the DP worksheet in addition to the supply and demand for each node. Each arc has a capacity per hour. The Capacity for each arc is equal to the "Capacity per Hour * Number of Hours".

22. (2 pts. for feasibility, 3 pts. for consistency, 2 pts. for optimality) Complete the model and run solver to minimize the Number of Hours it takes fans to get to their seats. Report the flow along each arc, the capacity of each arc, and the Number of Hours the gates must be open.

Predictive Analytics (8 pts.)

Asgard Bank offers car loans to its customers. A bank analyst has randomly selected 10 past car loans in which the customer defaulted (failed to pay off the loan) and 10 past car loans in which the customer did not default. The loan amount and the customer's credit score at the time when they applied for the loan are shown in the PA worksheet. This is our training set. The credit score is a number between 300 and 900, where 900 is a perfect credit score.

We would like to find a dividing line $c_1 \times$ Loan Amount + $c_2 \times$ Credit Score = b to help predict whether a customer will default.

We will predict "no default" if $c_1 \times$ Loan Amount + $c_2 \times$ Credit Score > b and we will predict "default" if $c_1 \times$ Loan Amount + $c_2 \times$ Credit Score < b.

23. (4 pts.) Suppose that $c_1 = -0.02$, $c_2 = 0.8$, and b = 200. Using these parameters, fill in the confusion matrix, based on the training set.

24. (2 pts. for feasibility, 1 pt. for consistency, 1 pt. for optimality) Find a dividing line that minimizes the number of misclassification errors. Report c_1, c_2, b, the binary misclassification variables, and the number of errors.

Inventory Management (7 pts.)

For an inventory system assume the following:

- S = $750 per order
- H = $1.5 per unit per year
- LT = 7 days
- D = 684,422 units per year
- One year has 365 days

25. (2 pts.) Use the EOQ model to calculate the optimal order quantity, Q*, rounded to a whole number, and the optimal reorder point, ROP*. You do not need to round ROP*.

26. (1 pt.) What is annual relevant cost based on the Q* and ROP* you found in the previous question?

The "IM" worksheet has the LTD model, populated with 2 years of demand values.

27. (1 pt.) What is the fill rate associated with the Q* and ROP*?

28. (1 pt.) Find the smallest ROP in multiples of hundred that results in a fill rate of at least 99%. We call this revised ROP*. Use Q* you found in Question 25.

29. (1 pt.) Based on Q* you found in Question 25 and the revised ROP* you found in Question 28, what is the average inventory?

30. (1 pt.) Calculate the increase in total costs associated with increasing the reorder point from ROP* to revised ROP*.

Congestion Management (7 pts.)

Patients in a hospital ward (4 pts.)

A hospital ward has 35 patients and 4 nurses. Each patient has a button by their bed that they can use to request assistance from one of the nurses. Each nurse can provide assistance to 5 patients per hour, on average. The average time from when a patient has received assistance from a nurse until the next time that patient requests assistance is 2 hours. By using the correct waiting line analysis template for this situation, it has been determined that on average, patients have to wait 0.0731 hours (4.39 minutes) to obtain assistance from a nurse.

31. (1 pt.) What is the correct template to use?

a) MMs
b) MMs finite pop
c) MMs finite cap
d) MG1

32. (2 pts.) Report the inputs required for the correct template. Use one hour as the time unit.

33. (1 pt.) Suppose that 1 of the 4 nurses is absent. All other inputs remain the same. What is the new value for the average time, in hours, that patients have to wait to obtain assistance from a nurse?

Simulation model bug hunt (3 pts.)

The "CM bugs" worksheet contains calculations for the Asgard Bank simulation model. The cells in this sheet contain one or more errors. An error could be an incorrect formula, a formula where there should be a number, or a number where there should be a formula.

34. (3 pts.) Report the cells that you think have errors. To report a cell, type its cell reference. For example, type A1 if you think there is an error in cell A1. If an incorrect formula is propagated to other cells in a range then report only the first cell in the range. You might not need all of the answer cells provided.

Your mark for this question will equal MAX(0, X * (right – wrong)) where "right" is the number of errors you found and "wrong" is the number of instances where you reported an error in a cell that does not have an error. We do not tell you the value of X to avoid giving away information about how many errors the model has.