Section A (30 points total, each question 3 points)

All Questions are compulsory. Each question in section A is for 3 Points. There is no negative marking. Incorrect responses get 0 points. Write the question number and your answer (in UPPER CASE letter) in the answer booklet.

Please answer Q1 and Q2 based on the problem definition below.

Due to increased sales, a company is considering building three new distribution centres (DCs) to serve four regional sales areas. The annual cost to operate DC 1 is $500 (in thousands of dollars). The cost to operate DC 2 is $600 (in thousands of dollars.). The cost to operate DC 3 is $525 (in thousands of dollars). Assume that the variable cost of operating at each location is the same, and therefore not a consideration in making the location decision.

The table below shows the cost ($ per item) for shipping from each DC to each region.

DC	A	B	C	D
1	1	3	3	2
2	2	4	1	3
3	3	2	2	3

The demand for region A is 70,000 units; for region B, 100,000 units; for region C, 50,000 units; and for region D, 80,000 units. Assume that the capacity for each distribution centre will be 500,000 units.

Q1 Suppose that an integer programming model has been proposed to solve this problem as below:

1) x_i = 1 if DC i is opened, 0 otherwise (i = 1, 2, 3)
   y_{ij} = # units transported from DC i to sales area j, j = A, B, C, D
2) Minimize Z = $\sum_i Annual\ cost\ to\ operate\ DC\ i * x_i + \sum_{i,j} Transportation\ cost\ from\ DC\ i\ to\ sales\ area\ j * y_{ij}$
3) $\sum_i y_{ij} = Demand\ at\ sales\ area\ j$ for all j
4) $\sum_i y_{ij} \leq Capacity\ at\ DC\ i$ for all i
5) $y_{ij} \geq 0$ and integer

Which one of the lines above (denoted with their corresponding numbering) are incorrectly written to model this problem?

A) 1
B) 2
C) 3
D) 4

Q2 Based on the answer report below, which one of these statements below is incorrect?

ɔjective Cell (Min)

Cell	Name	Original Value	Final Value
$E$16	Total Cost	480	1180

ıriable Cells

Cell	Name	Original Value	Final Value	Integer
$I$3	DC Selection 1	0	1	Binary
$I$4	DC Selection 2	0	0	Binary
$I$5	DC Selection 3	0	0	Binary
$H$8	DC 1 to A	0	70	Contin
$I$8	DC 1 to B	0	100	Contin
$J$8	DC 1 to C	0	50	Contin
$K$8	DC 1 to D	0	80	Contin
$H$9	DC 2 to A	0	0	Contin
$I$9	DC 2 to B	0	0	Contin
$J$9	DC 2 to C	0	0	Contin
$K$9	DC 2 to D	0	0	Contin
$H$10	DC 3 to A	0	0	Contin
$I$10	DC 3 to B	0	0	Contin
$J$10	DC 3 to C	0	0	Contin
$K$10	DC 3 to D	0	0	Contin

ınstraints

Cell	Name	Cell Value	Formula	Status	Slack
$E$8	Total shipped from DC 1	300	$E$8<=$M$8	Not Binding	200
$E$9	Total shipped from DC 2	0	$E$9<=$M$9	Binding	0
$E$10	Total shipped from DC 3	0	$E$10<=$M$10	Binding	0
$F$12	Total shipped to A	70	$F$12=$F$14	Binding	0
$G$12	Total shipped to B	100	$G$12=$G$14	Binding	0
$H$12	Total shipped to C	50	$H$12=$H$14	Binding	0
$I$12	Total shipped to C	80	$I$12=$I$14	Binding	0
$I$3:$I$5=Binary					

A) The solution used only one distribution centre.

B) The number of distribution centres activated would not change if demands at each sales area would increase by 50(thousands) each.

C) The solution (i. e. which DCs to open and transported amounts) would change if the cost of operating distribution centre 1 is increased to $520.

D) None of the DCs is dominantly advantageous in terms of transportation costs (i. e. has lower costs compared to others for all sales areas).

Q3 Which one of these is not correct for nonlinear and linear programming models?

A) For the decision variable x, $Z = -20x^2 + 40Cx + 120x - 200$, cannot represent the objective function in linear programming model.
B) For a situation where demand is related to the price such that (Demand = 1000 – 8*price), profit maximization cannot be modelled with linear programming.
C) For a case where minimizing variance of a Key Performance Indicator (KPI) is of concern, nonlinear programming should be the preferred method.
D) A portfolio maximization model requires the use of linear programming if portfolio variance is to be minimized.

Please answer Q4 and Q5 based on the problem definition below.

A manufacturing company produces products 1, 2, and 3. The three products have the following resource requirements and produce the following profit:

Product	Labour (hr./unit)	Material A (lb./unit)	Material B (lb./unit)	Profit ($/unit)
1	5	4	2	$3
2	2	6	4	$5
3	4	3	3	$2

At present, the firm has a daily labour capacity of 240 available hours and a daily supply of 400 pounds of material A and 300 pounds of material B. Management has developed the following set of goals, arranged in order of their importance to the firm:

(1) Management has established a satisfactory profit level of $500 per day (PL). (P=2)

(2) Overtime is to be minimized as much as possible (OT). (P=1)

(3) Management wants to minimize the purchase of additional material A to avoid handling and storage problems (MA). (P=1)

Q4 Suppose that x_i: production amount (i = 1, 2, 3) and s_j^- is underachievement and s_j^+ is overachievement for constraint related with a resource/parameter j (j = PL, OT, and MA). Which one of the lines below would be an incorrect element of the goal programming model?

A) Minimize $Z = 2\, s_{PL}^+ + s_{OT}^+ + s_{MA}^+$
B) $3x_1 + 5x_2 + 2x_3 + s_{PL}^- - s_{PL}^+ = 500$
C) $5x_1 + 2x_2 + 4x_3 + s_{OT}^- - s_{OT}^+ = 240$
D) $4x_1 + 6x_2 + 3x_3 + s_{MA}^- - s_{MA}^+ = 400$

Q5 Based on the Answer report below, which one of the changes below in resource/aspiration levels would require a change in the current optimal solution?

Objective Cell (Min)

Cell	Name	Original Value	Final Value
$D$14	Obj Fnc. x2	0	0

Variable Cells

Cell	Name	Original Value	Final Value	Integer
$C$9	x1	34	34	Integer
$D$9	x2	33	33	Integer
$E$9	x3	0	0	Integer
$F$9	sPL-	0	0	Contin
$G$9	sPL+	233	233	Contin
$H$9	sOT-	4	4	Contin
$I$9	sOT+	0	0	Contin
$J$9	sMA-	66	66	Contin
$K$9	sMA+	0	0	Contin

Constraints

Cell	Name	Cell Value	Formula	Status	Slack
$M$12		200	$M$12<=$O$12	Binding	0
$M$9		500	$M$9=$O$9	Binding	0
$M$10		240	$M$10=$O$10	Binding	0
$M$11		400	$M$11=$O$11	Binding	0
$C$9:$E$9=Integer					

A) Increasing the aspiration level of profit to $700.
B) Increasing the number of available labour hours
C) Increasing the amount of available material A
D) Increasing the amount of available material B

Please answer Q6 and Q7 based on the problem definition below.

Brenda is considering her course(module) selection among the ones listed below for her upcoming semester.

Course(module) Name	Type
A. Management I	Qualitative
B. Principles of Accounting	Quantitative
C. Corporate Finance	Quantitative
D. Quantitative Methods	Quantitative
E. Marketing Management	Qualitative
F. Java Programming	Quantitative
G. English Literature	Qualitative

Q6 E. Marketing Management and B. Principles of Accounting are at the same time slot, and B. Principles of Accounting and C. Corporate Finance are co-requisites, meaning that they need to be taken at the same time. If the decision to select the courses(modules) are represented via binary variables, which one the constraint pairs below would represent the requirements below?

A) $E + B \leq 2, B \leq C$
B) $E + B \leq 1, B = C$
C) $E + B \geq 1, C \leq B$
D) $E + B = 2, B = C$

Q7 Brenda wanted to take at most three quantitative modules originally, but then she decided to change her preference on this to: at most two quantitative modules and at least one qualitative module; what would be the correct original and updated versions of this constraint?

A) Change $B + C + D + F \leq 3$ to $B + C + D + F \leq 2$ and $A + E + G \geq 1$
B) Change $B + C + D + F = 3$ to $B + C + D + F \leq 2$ and $A + E + G = 1$
C) Change $B + C + D + F \leq 3$ to $B + C + D + F \leq 2$ and $A + E + G \leq 1$
D) Change $B + C + D + F = 3$ to $B + C + D + F = 2$ and $A + E + G \geq 1$

Q8 A marketing research analyst is working with a client for their customer loyalty and retention program. The program has a target of keeping a customer for a minimum number of years with the company over the registered customer base. For the variable: the number of years with the company, which one of the measures (main statistics) listed below would be less relevant to report than the others?

A) Minimum
B) Maximum
C) 5^{th} percentile
D) Median

Please answer Q9 and Q10 based on the scenario below.

A consultant is working on how to increase the daily sales and service level at a fast-food restaurant. The restaurant is considering recruiting additional part-time personnel to prevent prospective customers from leaving without ordering at rush hours.

Q9 Which distribution would be less preferable to simulate the daily demand for a meal?

A) Normal
B) Gamma
C) Binomial
D) Poisson

Q10 Suppose that the restaurant manager does not have sufficient data on the service time per customer for the performance of a prospective employee. Instead, he makes educated guesses about the minimum, maximum, and most likely values of the service time per customer based on his/her past observations. In this case, which distribution would be most appropriate to simulate the service time?

A) Triangular
B) Discrete Uniform
C) Exponential
D) Normal