Birla Institute of Technology and Science, Pilani
Analytics for Supply Chain (BITS F455)
Comprehensive Exam (Open Book)

Time: 3 Hrs **Max. Marks 35**

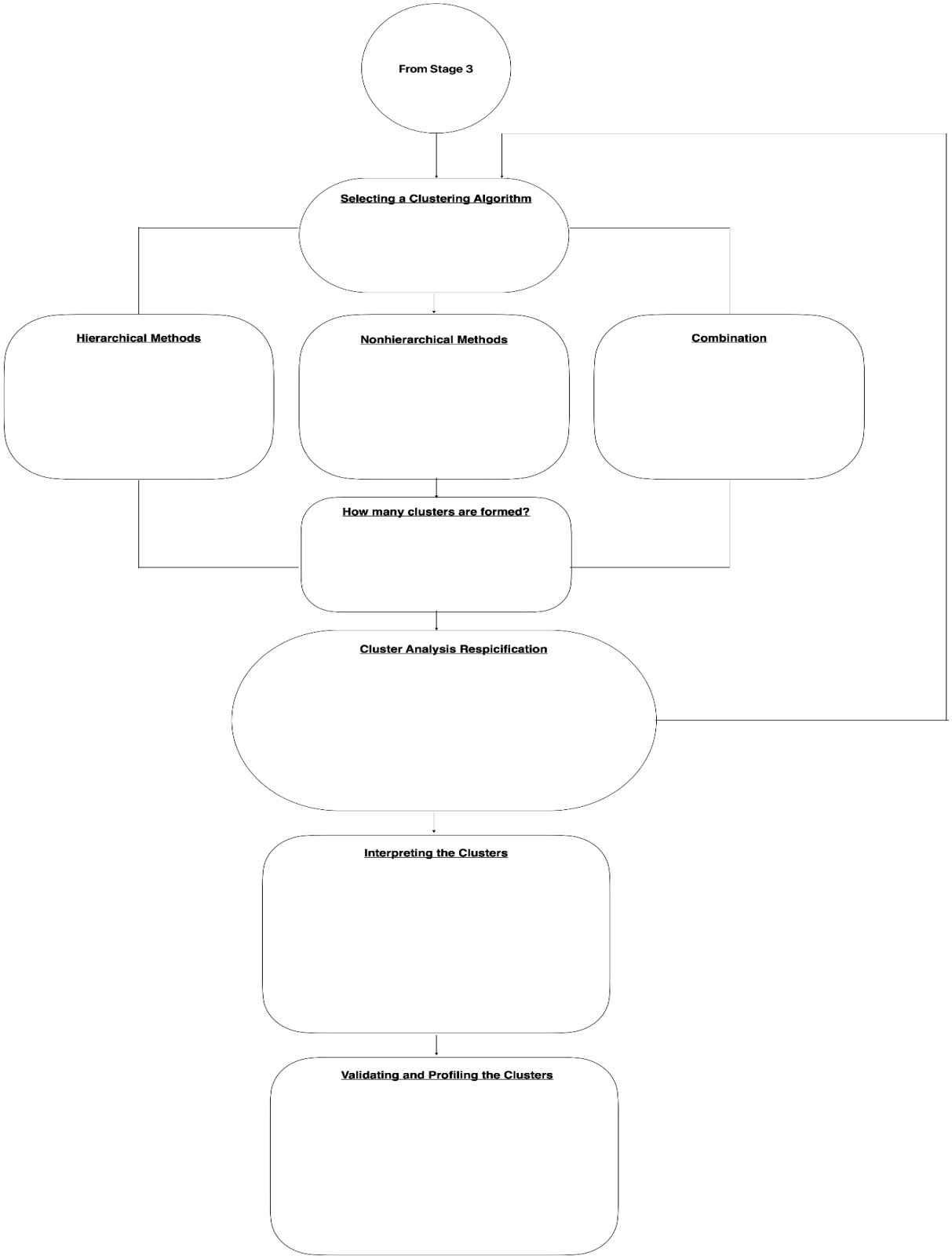
Each question carry equal marls and question carry 5 marks weightage

Q.1) A Major supermarket chain wants to determine the effect of promotion on relative competitiveness. Data were obtained from 15 states on the promotional expenses relative to a major competitor (competitor expenses = 100) and on sales relative to this competitor (competitor sales = 100).

State No.	Relative Promotional Expense	Relative Sales
1	95	98
2	92	94
3	103	110
4	115	125
5	77	82
6	79	84
7	105	112
8	94	99
9	85	93
10	101	107
11	106	114
12	120	132
13	118	129
14	75	79
15	99	105

You are assigned the task of telling the manager whether there is any relationship between relative promotional expense and relative sales.

Q.2) Go through Stages of the Cluster analysis shown in Decision Diagram. Complete each steps by providing more details about each step.


From Stage 3
Selecting a Clustering Algorithm
Hierarchical Methods
Nonhierarchical Methods
Combination
How many clusters are formed?
Cluster Analysis Respicification
Interpreting the Clusters
Validating and Profiling the Clusters

Q.3) VARIMAX-Rotated Component Analysis Factor Matrices: Full and Reduced Sets of Variables Calculate the sum of squares and percentage of trace.

	VARIMAX-ROTATED LOADINGS				
	Factor				
Full Set of Variables	**1**	**2**	**3**	**4**	**Communality**
X18 Delivery Speed	0.938	0.177	-0.005	0.052	0.914
X9 Complaint Resolution	0.926	0.116	0.048	0.091	0.881
X16 Order & Billing	0.864	0.107	0.084	-0.039	0.766
X12 Salesforce Image	0.133	0.900	0.076	-0.159	0.859
X7 E-Commerce	0.057	0.871	0.047	-0.117	0.777
X10 Advertising	0.139	0.742	-0.082	0.015	0.576
X8 Technical Support	0.018	-0.024	0.939	0.101	0.893
X14 Warranty & Claims	0.110	0.055	0.931	0.102	0.892
X6 Product Quality	0.002	-0.013	-0.033	0.876	0.768
X13 Competitive Pricing	-0.085	0.226	-0.246	-0.723	0.641
X11 Product Line	0.591	-0.064	0.146	0.642	0.787
					Total
Sum of Squares (eigenvalue)	-	-	-	-	
Percentage of trace					

Show the loadings which are significant of each variables and name the factors appropriately.

	VARIMAX-ROTATED LOADINGS				
	Factor				
Reduced Set of Variables					
(X11 deleted)					0.89
X9 Complaint Resolution					0.894
X18 Delivery Speed					0.806
X16 Order & Billing					0.86
X12 Salesforce Image					0.78
X7 E-Commerce					0.585
X10 Advertising					0.894
X8 Technical Support					0.891
X14 Warranty & Claims					0.798

X6 Product Quality					0.661
X13 Competitive Pricing					
					Total
Sum of Squares (eigenvalue)	2.589	2.216	1.846	1.406	8.057
Percentage of trace	25.89	22.16	18.46	14.06	80.57

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Q. 4) Design the vehicle route for a consumer goods com-any that has 10 dealers. The capacity of the vehicle is 25 units and other relevant data are as follows:

Distance- and load-related data for a consumer goods company.

Dealer	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Distance from depot	16	18	10	17	26	18	7	12	15	21
Average demand (tons)	8	4	6	6	4	8	8	6	8	4

Distance matrix in kilometers

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1										
2	34									
3	7	**27**								
4	33	12	27							
5	41	8	35	19						
6	31	13	24	23	14					
7	19	20	14	15	28	24				
8	24	20	19	12	28	27	6			
9	12	32	12	26	40	33	12	15		
10	32	23	28	12	31	33	15	9	22	

Apart from capacity constraints, how will your answer change if we put an additional constraint saying that route length should not exceed 45 km?

Q. 5) Infocomp Systems Lab is a research and development (R&D company that develops computer systems and software primarily for the medical industry. The lab has proposals from its researchers for eight new projects. Each of the proposed research projects requires limited resources, and it is not possible to undertake all of them. The following table shows the developmental budget, the number of researchers, and the expected annual sales from each project successfully developed and implemented:

Project	Developmental Budget ($1,000,000s)	Number of Research Personnel	Expected Annual Sales ($1,000,000s)
1	$0.675	6	$0.82
2	1.050	5	1.75
3	0.725	7	1.60
4	0.430	8	1.90
5	1.240	10	0.93
6	0.890	6	1.70
7	1.620	7	1.30
8	1.200	6	1.80

The lab has developed the following set of prioritized goals for selecting which projects initiate:

1. The company would like to remain within a total developmental budget of $5,000,000.
2. The number of available research personnel is 27, and Infocomp would like to avoid obtaining extra researchers.
3. The company would like the expected future annual sales from the implemented projects I be at least $6,500,000.
4. Projects 1, 3, 4, and 6 are considered offensive in that they represent new product initiatives while projects 2, 5, 7, and 8 are existing product upgrades and thus defensive in nature. TI lab would like to select at least two projects from each group.

5. Projects 2, 3, 5, 6, and 7 are considered the most risky of the projects, and the companies would prefer not to select any more than three of these projects.
6. The lab's owner has indicated that she would like to see projects 5 and 6 initiated if doing so would not interfere with the achievement of any of the more important goals determined by the lab's top management.
    a) Formulate a goal programming model to determine which projects Infocomp Systems La should select to best achieve its goals.
    b) Solve this model by using the computer. (Note that the solution requires 0-1 integer value for the variables in the model.)

Q.6) A local bank has a single drive-through window with arrival times and service times that follow the distributions from the following table:

TIME BETWEEN ARRIVALS (MIN.)	PROBABILITY	SERVICE TIME (MIN.)	PROBABILITY
1	0.15	1	0.15
2	0.24	2	0.35
3	0.27	3	0.22
4	0.22	4	0.28
5	0.12		

Simulate the arrival of 200 customers to compute each of the following measures:
(a) average time a customer waits for service, (b) average time a customer is in the system (wait plus service time), and (c) percentage of time the server is busy with customers. Replicate each measure N times to compute the average.

OR

Q.6) Erik Marshall owns and operates one of the largest BMW auto dealerships in St. Louis. In the past 36 months, his weekly sales of Z3s have ranged from a low of 6 to a high of 12, as reflected in the following table:

Z3 SALES PER WEEK	FREQUENCY
6	3
7	4
8	6
9	12
10	9
11	1
12	1

Erik believes that sales will continue during the next 24 months at about the same rate and that delivery lead times will also continue to follow this pace (stated in probability form):

DELIVERY TIME (WEEKS)	PROBABILITY
1	0.44
2	0.33
3	0.16
4	0.07

Erik's current policy is to order 14 autos at a time (two full truckloads, with 7 autos on each truck) and to place a new order whenever the stock on hand reaches 12 autos. Beginning

inventory is 14 autos. Erik establishes the following relevant costs: (i) The carrying cost per Z3 per week is $400, (ii) the cost of a lost sale averages $7,500, and (iii) the cost of placing an order is $1,000.

(a) Simulate Erik's inventory policy for the next two years. What is the total weekly cost of this policy? Also, what is the average number of stockouts per week? Use N replications of your model.

(b) Erik wishes to evaluate several different ordering quantities—12, 14, 16, 18, and 20. Based on the total weekly cost, what would you recommend? Why? Set R = 12 in each case.

Q.7 See ACF and PACF plots shown and Identify the Appropriate short term time series forecasting model?