

[This question paper contains 8 printed pages.]



Sr. No. of Question Paper : 1143

Unique Paper Code : 2922062401

Name of the Paper : Quantitative Techniques for Management

Name of the Course : BMS

Semester : IV

Duration : 3 Hours

Maximum Marks : 90

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt any five questions in all.
3. All questions carry equal marks.
4. Use of Simple calculators are allowed.
5. Use of standard normal table is allowed.

1. Consider the following Linear Programming Problem :

Minimize $Z = 2x_1 + 3x_2 + 4x_3$

Subject to :

$$x_1 + x_2 + x_3 \geq 5$$

$$x_1 + x_2 + 2x_3 \geq 5$$

$$x_1, x_2, x_3 \geq 0$$

(i) Solve the above problem using Big M Simplex Method.

(ii) Determine whether the problem has a unique optimal solution or multiple optimal solutions. Justify your answer.

(iii) What is degeneracy? Determine whether the solution obtained above is degenerate.

(18)

P.T.O.

2. (a) What are the steps involved in the formulation of a Linear Programming model? Illustrate these steps with the help of the following situation and solve the resulting problem graphically.

Mr. Gopal has received an inheritance of ₹95,000, which he plans to invest for one year in two alternatives - land and a small retail business. Each rupee invested in land yields a return of 20%, while each rupee invested in the retail business yields a return of 30%. Since both investments involve risk, Mr. Gopal wants to limit his overall exposure. He estimates that the risk associated with land is 18% of the amount invested, while for the retail business it is 30%. He does not want the total risk to exceed ₹20,000.

- (b) A firm is considering four pricing strategies – A1, A2, A3, and A4 to compete in the market. Its competitor may respond with either an aggressive strategy B1 or a passive strategy B2. Based on market analysis, the firm estimates that if the competitor adopts an aggressive strategy, the payoffs (in ₹ lakhs) corresponding to A1, A2, A3, and A4 are 2, 4, 10, and 6 respectively. If the competitor adopts a passive strategy, the corresponding payoffs are 10, 5, 2, and 4, respectively. Assuming that the situation can be modeled as a two-person zero-sum game, formulate the payoff matrix and solve the game using the graphical method. Determine the optimal strategies and the value of the game. (9+9)

3. Consider the following LPP:

$$\text{Min } Z = 14x_1 - 10x_2 + 18x_3$$

$$\text{s.t. } 2x_1 - x_2 + 3x_3 \geq 9$$

$$x_1 - 2x_2 + x_3 \geq 4$$

$$\text{where } x_1, x_2, x_3 \geq 0$$

The final optimal solution table for the LPP is given below :

Basic Variables	C_B	x_1	x_2	x_3	S_1	A_1	S_2	A_2	b_i
x_3	18	0	3	1	-1	1	2	-2	1
x_1	14	1	-5	0	1	-1	-3	3	3
Z_j		14	-16	18	-4	4	-6	6	
$C_j - Z_j$		0	6	0	4	M-4	6	M-6	

- (i) Write the dual to the above primal and explain the relationship between the primal and the dual. State the solution to the dual and show that it gives the same objective function value as that of the primal.
- (ii) Comment whether the constraints are binding or non-binding giving suitable justification.
- (iii) State the range within which change in objective function coefficients for variables X_2 and X_3 will not affect the optimal solution obtained above. (18)

4. A company has factories at three different places S_1 , S_2 and S_3 and supply markets at four destinations D_1 , D_2 , D_3 and D_4 . Monthly factory capacities are 250, 350 and 300 units respectively. Monthly requirements at demand centres are 200, 240, 210 and 250 units respectively. The per unit profit for different supply centre and market combinations are provided in the table below. For certain reasons the supply route from source S_2 to market D_3 is unavailable.

Profit (in Rs. per unit)

	D1	D2	D3	D4
S1	12	8	15	9
S2	10	14	X	11
S3	16	9	13	7

- (i) Formulate the above as a transportation problem. Find the initial basic feasible solution to the transportation problem using Vogel's Approximation Method.

- (ii) Explain the procedure for testing a transportation solution for optimality using Modified Distribution Method. Also state the rules for constructing a closed loop to transfer quantities for finding an improved/alternate solution.

- (iii) Find the optimal transportation schedule that will maximise total profit. Comment if the optimal solution is unique or multiple. Find the alternate optimal solution if any. (18)

5. (a) A municipal council has received a special grant of Rs. 10 lakhs for carrying out maintenance work on five public parks in the city. The work must be completed at the minimum possible cost and in the least possible time. If needed, a supplementary token grant may also be considered. Six service agencies have submitted bids and each park can be assigned to only one agency.

- (i) Find the best way of assigning the maintenance work to the agencies and the total cost.

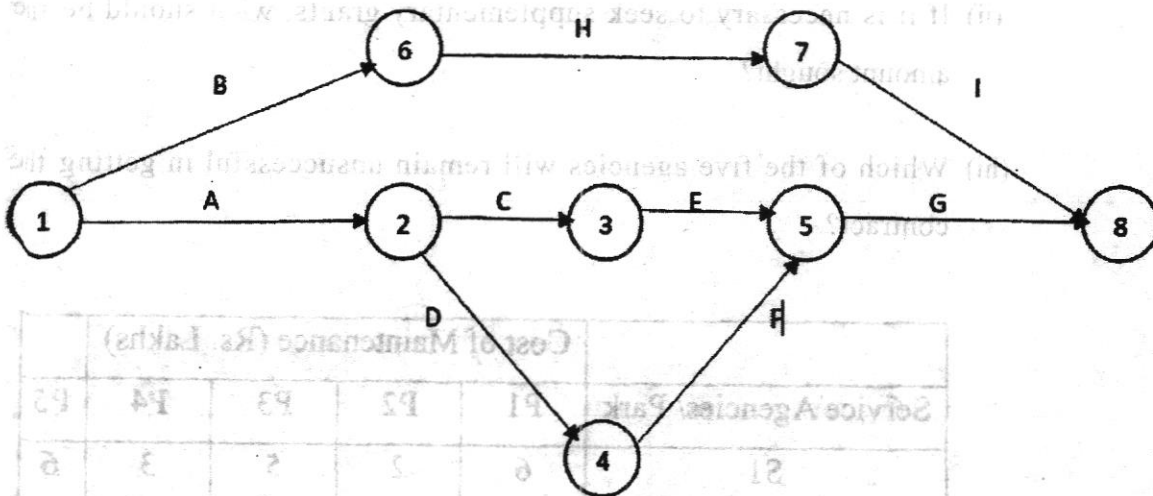
(ii) If it is necessary to seek supplementary grants, what should be the amount sought?

(iii) Which of the five agencies will remain unsuccessful in getting the contract?

Service Agencies/ Park	Cost of Maintenance (Rs. Lakhs)				
	P1	P2	P3	P4	P5
S1	6	2	5	3	6
S2	2	5	8	7	7
S3	7	8	6	9	8
S4	6	2	3	4	5
S5	9	3	8	9	7
S6	4	7	4	6	8

(b) A project has nine activities with the following time estimates (in weeks) and the project network :

Activity	Most Optimistic Time	Most Likely Time	Most Pessimistic Time
A	3	6	15
B	2	5	14
C	6	12	30
D	2	5	8
E	5	11	17
F	3	6	15
G	1	4	7
H	3	9	27
I	4	19	28



- (i) Determine the critical path, expected duration and variance of the project.
- (ii) If a 31-week deadline is imposed, then what is the probability that the project will be finished within the time limit?
- (iii) If the project manager wants to be 99% sure that the project is completed on the scheduled date, how many weeks before that date should he start the project work? (9+9)

6. The following table shows details of a project.

Activities	Immediate Predecessor	Normal Time (days)	Crash Time (days)	Crash Slope (Rs./day)
A	-	3	1	2000
B	A	4	3	6000
C	A	3	2	2000
D	A	8	7	1000
E	B	4	4	-
F	C	6	6	-
G	E,F	5	4	4000
H	D	3	1	1800

Compute the following :

- (i) Draw a network diagram representing the project.
- (ii) Calculate the Earliest and Latest event times and Total Float of the project.
- (iii) Determine the Critical Path and Total Duration of the project.

- (iv) Determine a crashing scheme for the above project so that the total project time is reduced by 4 days and the associated cost. (18)

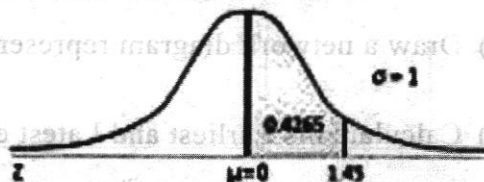
Activity	Duration	ES	EF	LS	LF	TF	FF
1	4	0	4	0	4	0	4
2	3	4	7	4	7	0	7
3	5	0	5	0	5	0	5
4	6	5	11	5	11	0	11
5	2	7	9	7	9	0	9
6	4	4	8	4	8	0	8
7	3	8	11	8	11	0	11
8	5	11	16	11	16	0	16
9	2	9	11	9	11	0	11
10	4	11	15	11	15	0	15
11	3	15	18	15	18	0	18
12	2	16	18	16	18	0	18
13	4	18	22	18	22	0	22
14	3	18	21	18	21	0	21
15	2	21	23	21	23	0	23
16	4	22	26	22	26	0	26
17	3	26	29	26	29	0	29
18	2	29	31	29	31	0	31
19	4	31	35	31	35	0	35
20	3	35	38	35	38	0	38
21	2	38	40	38	40	0	40
22	4	40	44	40	44	0	44
23	3	44	47	44	47	0	47
24	2	47	49	47	49	0	49
25	4	49	53	49	53	0	53
26	3	53	56	53	56	0	56
27	2	56	58	56	58	0	58
28	4	58	62	58	62	0	62
29	3	62	65	62	65	0	65
30	2	65	67	65	67	0	67
31	4	67	71	67	71	0	71
32	3	71	74	71	74	0	74
33	2	74	76	74	76	0	76
34	4	76	80	76	80	0	80
35	3	80	83	80	83	0	83
36	2	83	85	83	85	0	85
37	4	85	89	85	89	0	89
38	3	89	92	89	92	0	92
39	2	92	94	92	94	0	94
40	4	94	98	94	98	0	98
41	3	98	101	98	101	0	101
42	2	101	103	101	103	0	103
43	4	103	107	103	107	0	107
44	3	107	110	107	110	0	110
45	2	110	112	110	112	0	112
46	4	112	116	112	116	0	116
47	3	116	119	116	119	0	119
48	2	119	121	119	121	0	121
49	4	121	125	121	125	0	125
50	3	125	128	125	128	0	128
51	2	128	130	128	130	0	130
52	4	130	134	130	134	0	134
53	3	134	137	134	137	0	137
54	2	137	139	137	139	0	139
55	4	139	143	139	143	0	143
56	3	143	146	143	146	0	146
57	2	146	148	146	148	0	148
58	4	148	152	148	152	0	152
59	3	152	155	152	155	0	155
60	2	155	157	155	157	0	157
61	4	157	161	157	161	0	161
62	3	161	164	161	164	0	164
63	2	164	166	164	166	0	166
64	4	166	170	166	170	0	170
65	3	170	173	170	173	0	173
66	2	173	175	173	175	0	175
67	4	175	179	175	179	0	179
68	3	179	182	179	182	0	182
69	2	182	184	182	184	0	184
70	4	184	188	184	188	0	188
71	3	188	191	188	191	0	191
72	2	191	193	191	193	0	193
73	4	193	197	193	197	0	197
74	3	197	200	197	200	0	200
75	2	200	202	200	202	0	202
76	4	202	206	202	206	0	206
77	3	206	209	206	209	0	209
78	2	209	211	209	211	0	211
79	4	211	215	211	215	0	215
80	3	215	218	215	218	0	218
81	2	218	220	218	220	0	220
82	4	220	224	220	224	0	224
83	3	224	227	224	227	0	227
84	2	227	229	227	229	0	229
85	4	229	233	229	233	0	233
86	3	233	236	233	236	0	236
87	2	236	238	236	238	0	238
88	4	238	242	238	242	0	242
89	3	242	245	242	245	0	245
90	2	245	247	245	247	0	247
91	4	247	251	247	251	0	251
92	3	251	254	251	254	0	254
93	2	254	256	254	256	0	256
94	4	256	260	256	260	0	260
95	3	260	263	260	263	0	263
96	2	263	265	263	265	0	265
97	4	265	269	265	269	0	269
98	3	269	272	269	272	0	272
99	2	272	274	272	274	0	274
100	4	274	278	274	278	0	278
101	3	278	281	278	281	0	281
102	2	281	283	281	283	0	283
103	4	283	287	283	287	0	287
104	3	287	290	287	290	0	290
105	2	290	292	290	292	0	292
106	4	292	296	292	296	0	296
107	3	296	299	296	299	0	299
108	2	299	301	299	301	0	301
109	4	301	305	301	305	0	305
110	3	305	308	305	308	0	308
111	2	308	310	308	310	0	310
112	4	310	314	310	314	0	314
113	3	314	317	314	317	0	317
114	2	317	319	317	319	0	319
115	4	319	323	319	323	0	323
116	3	323	326	323	326	0	326
117	2	326	328	326	328	0	328
118	4	328	332	328	332	0	332
119	3	332	335	332	335	0	335
120	2	335	337	335	337	0	337
121	4	337	341	337	341	0	341
122	3	341	344	341	344	0	344
123	2	344	346	344	346	0	346
124	4	346	350	346	350	0	350
125	3	350	353	350	353	0	353
126	2	353	355	353	355	0	355
127	4	355	359	355	359	0	359
128	3	359	362	359	362	0	362
129	2	362	364	362	364	0	364
130	4	364	368	364	368	0	368
131	3	368	371	368	371	0	371
132	2	371	373	371	373	0	373
133	4	373	377	373	377	0	377
134	3	377	380	377	380	0	380
135	2	380	382	380	382	0	382
136	4	382	386	382	386	0	386
137	3	386	389	386	389	0	389
138	2	389	391	389	391	0	391
139	4	391	395	391	395	0	395
140	3	395	398	395	398	0	398
141	2	398	400	398	400	0	400
142	4	400	404	400	404	0	404
143	3	404	407	404	407	0	407
144	2	407	409	407	409	0	409
145	4	409	413	409	413	0	413
146	3	413	416	413	416	0	416
147	2	416	418	416	418	0	418
148	4	418	422	418	422	0	422
149	3	422	425	422	425	0	425
150	2	425	427	425	427	0	427
151	4	427	431	427	431	0	431
152	3	431	434	431	434	0	434
153	2	434	436	434	436	0	436
154	4	436	440	436	440	0	440
155	3	440	443	440	443	0	443
156	2	443	445	443	445	0	445
157	4	445	449	445	449	0	449
158	3	449	452	449	452	0	452
159	2	452	454	452	454	0	454
160	4	454	458	454	458	0	458
161	3	458	461	458	461	0	461
162	2	461	463	461	463	0	463
163	4	463	467	463	467	0	467
164	3	467	470	467	470	0	470
165	2	470	472	470	472	0	472
166	4	472	476	472	476	0	476
167	3	476	479	476	479	0	479
168	2	479	481	479	481	0	481
169	4	481	485	481	485	0	485
170	3	485	488	485	488	0	488
171	2	488	490	488	490	0	490
172	4	490	494	490	494	0	494
173	3	494	497	494	497	0	497
174	2	497	499	497	499	0	499
175	4	499	503	499	503	0	503
176	3	503	506	503	506	0	506
177	2	506	508	506	508	0	508
178	4	508	512	508	512	0	512
179	3	512	515	512	515	0	515
180	2	515	517	515	517	0	517
181	4	517	521	517	521	0	521
182	3	521	524	521	524	0	524
183	2	524	526	524	526	0	526
184	4	526	530	526	530	0	530
185	3	530	533	530	533	0	533
186	2	533	535	533	535	0	535
187	4	535	539	535	539	0	539
188	3	539	542	539	542	0	542
189	2	542	544	542	544	0	544
190	4	544	548	544	548	0	548

Areas Under the One-Tailed Standard Normal Curve

This table provides the area between the mean and some Z score.

For example, when Z score = 1.45

the area = 0.4265.



Z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.0000	0.0040	0.0080	0.0120	0.0160	0.0199	0.0239	0.0279	0.0319	0.0359
0.1	0.0398	0.0438	0.0478	0.0517	0.0557	0.0596	0.0636	0.0675	0.0714	0.0753
0.2	0.0793	0.0832	0.0871	0.0910	0.0948	0.0987	0.1026	0.1064	0.1103	0.1141
0.3	0.1179	0.1217	0.1255	0.1293	0.1331	0.1368	0.1406	0.1443	0.1480	0.1517
0.4	0.1554	0.1591	0.1628	0.1664	0.1700	0.1736	0.1772	0.1808	0.1844	0.1879
0.5	0.1915	0.1950	0.1985	0.2019	0.2054	0.2088	0.2123	0.2157	0.2190	0.2224
0.6	0.2257	0.2291	0.2324	0.2357	0.2389	0.2422	0.2454	0.2486	0.2517	0.2549
0.7	0.2580	0.2611	0.2642	0.2673	0.2704	0.2734	0.2764	0.2794	0.2823	0.2852
0.8	0.2881	0.2910	0.2939	0.2967	0.2995	0.3023	0.3051	0.3078	0.3106	0.3133
0.9	0.3159	0.3186	0.3212	0.3238	0.3264	0.3289	0.3315	0.3340	0.3365	0.3389
1.0	0.3413	0.3438	0.3461	0.3485	0.3508	0.3531	0.3554	0.3577	0.3599	0.3621
1.1	0.3643	0.3665	0.3686	0.3708	0.3729	0.3749	0.3770	0.3790	0.3810	0.3830
1.2	0.3849	0.3869	0.3888	0.3907	0.3925	0.3944	0.3962	0.3980	0.3997	0.4015
1.3	0.4032	0.4049	0.4066	0.4082	0.4099	0.4115	0.4131	0.4147	0.4162	0.4177
1.4	0.4192	0.4207	0.4222	0.4236	0.4251	0.4265	0.4279	0.4292	0.4306	0.4319
1.5	0.4332	0.4345	0.4357	0.4370	0.4382	0.4394	0.4406	0.4418	0.4429	0.4441
1.6	0.4452	0.4463	0.4474	0.4484	0.4495	0.4505	0.4515	0.4525	0.4535	0.4545
1.7	0.4554	0.4564	0.4573	0.4582	0.4591	0.4599	0.4608	0.4616	0.4625	0.4633
1.8	0.4641	0.4649	0.4656	0.4664	0.4671	0.4678	0.4686	0.4693	0.4699	0.4706
1.9	0.4713	0.4719	0.4726	0.4732	0.4738	0.4744	0.4750	0.4756	0.4761	0.4767
2.0	0.4772	0.4778	0.4783	0.4788	0.4793	0.4798	0.4803	0.4808	0.4812	0.4817
2.1	0.4821	0.4826	0.4830	0.4834	0.4838	0.4842	0.4846	0.4850	0.4854	0.4857
2.2	0.4861	0.4864	0.4868	0.4871	0.4875	0.4878	0.4881	0.4884	0.4887	0.4890
2.3	0.4893	0.4896	0.4898	0.4901	0.4904	0.4906	0.4909	0.4911	0.4913	0.4916
2.4	0.4918	0.4920	0.4922	0.4925	0.4927	0.4929	0.4931	0.4932	0.4934	0.4936
2.5	0.4938	0.4940	0.4941	0.4943	0.4945	0.4946	0.4948	0.4949	0.4951	0.4952
2.6	0.4953	0.4955	0.4956	0.4957	0.4959	0.4960	0.4961	0.4962	0.4963	0.4964
2.7	0.4965	0.4966	0.4967	0.4968	0.4969	0.4970	0.4971	0.4972	0.4973	0.4974
2.8	0.4974	0.4975	0.4976	0.4977	0.4977	0.4978	0.4979	0.4979	0.4980	0.4981
2.9	0.4981	0.4982	0.4982	0.4983	0.4984	0.4984	0.4985	0.4985	0.4986	0.4986
3.0	0.4987	0.4987	0.4987	0.4988	0.4988	0.4989	0.4989	0.4989	0.4990	0.4990
3.1	0.4990	0.4991	0.4991	0.4991	0.4992	0.4992	0.4992	0.4992	0.4993	0.4993
3.2	0.4993	0.4993	0.4994	0.4994	0.4994	0.4994	0.4994	0.4995	0.4995	0.4995
3.3	0.4995	0.4995	0.4995	0.4996	0.4996	0.4996	0.4996	0.4996	0.4996	0.4997
3.4	0.4997	0.4997	0.4997	0.4997	0.4997	0.4997	0.4997	0.4997	0.4997	0.4998
3.5	0.4998	0.4998	0.4998	0.4998	0.4998	0.4998	0.4998	0.4998	0.4998	0.4998
3.6	0.4998	0.4998	0.4999	0.4999	0.4999	0.4999	0.4999	0.4999	0.4999	0.4999
3.7	0.4999	0.4999	0.4999	0.4999	0.4999	0.4999	0.4999	0.4999	0.4999	0.4999
3.8	0.4999	0.4999	0.4999	0.4999	0.4999	0.4999	0.4999	0.4999	0.4999	0.4999
3.9	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000