Reg. No.

MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL (A constituent unit of MAHE, Manipal)

V SEMESTER B. TECH (INDUSTRIAL & PRODUCTION ENGG.)

ONLINE END SEMESTER EXAMINATIONS,

30 JANUARY 2021

SUBJECT: OPERATIONS RESEARCH [MME 3156]

REVISED CREDIT SYSTEM

Time: 3 Hours

MAX. MARKS: 50

Instructions to Candidates:

- This Question paper has 7 pages.
- Answer ALL the questions.
- Clearly show all the calculations and steps used
- ✤ All questions carry equal marks.
- Missing data may be suitably assumed.
- Use accepted symbols for your answers. Else, define the symbol you are using.
- Page 6 and 7 are the Normal Distribution Tables
- Q1 A caterer is to organize garden parties for a week. He needs a total of 160, 120, 60, 90, 110, 100 and 120 fresh napkins during the seven days of the week. Each new napkin costs ₹ 3. He can use soiled napkins after getting them washed from a laundry. Ordinarily, washing charges are ₹ 0.60 per napkin and they are returned after four days. However, the laundry also provides express service at a cost of ₹ 1 per napkin, in which case they are returned after two days. Formulate the LPP model to determine the planning schedule the caterer should adopt to buy or send napkins to the laundry so as to minimize the cost.
- **Q2** A fertilizer manufacturing company produces three basic types of fertilizers A, B and C it uses nitrate, phosphate and potash for this purpose. The following data is provided.

					Availability
Ingredients	% in type A	% in type B	% in type C	Cost/ton (₹)	(tons)
Nitrate	5	10	15	10,000	1200
Phosphate	15	15	10	4000	1600
Potash	10	10	10	6000	1400
Inert	70	65	65	500	

The selling price of three fertilizers/ton is Rs.3000, ₹ 4000 and ₹ 5000. The company must produce at least 6000 tons of type A fertilizer. The company wants to maximize its profits. Advise the company how much quantity of three fertilizers they should produce.

Q3 A production centre wants to assign seven operators to seven different jobs as given below. The times taken by them for each job are as follows:

		Operator								
		01	02	03	04	05	06	07		
	Α	23	12	45	39	54	21	18		
	В	45	38	18	31	53	33	54		
	С	38	41	31	38	54	19	45		
Job	D	13	45	27	45	45	38	38		
	Ε	38	34	36	30	38	41	21		
	F	38	54	54	29	42	30	44		
	G	45	45	23	17	45	39	49		

Assign the jobs so that total operation time is minimum. Find the minimum total time for all the jobs. Find the increase in the minimum total time for all the jobs if job B has already been assigned to operator O7.

A company wishes to determine an investment strategy for each of the next four years. Five investment types have been selected, investment capital has been allocated for each of the coming four years and maximum investment levels have been established for each investment type. An assumption is that amounts invested in any year will remain invested until the end of the planning horizon of four years. The following table summarizes the data for this problem. The values in the body of the table represent net return on investment of one rupee up to the end of the planning horizon. For example, a rupee invested in investment type B at the beginning of year 1 will grow to ₹1.90 by the end of the fourth year, yielding a net return of ₹ 0.90.

Investment made at the	Net return data on investment					Rupees
beginning of the year			type			available (000's)
	А	В	С	D	E	
1	0.80	0.90	0.60	0.75	1.00	500
2	0.55	0.65	0.40	0.60	0.50	600
3	0.30	0.25	0.30	0.50	0.20	750
4	0.15	0.12	0.25	0.35	0.10	800
Maximum rupees investment (in 000's)	750	600	500	800	1000	

Determine the amount to be invested at the beginning of each year in each investment to maximize the net rupee return for the four – year period.

Q5 Observations of past data show the following patterns in respect of inter-arrival duration and service duration in a single channel queueing system. Using the random number table below. Simulate the queue behavior for a period of 60minutes and estimate the probability of the service being idle and then mean time spent by a customer waiting for service.

Inter-Arri	val Time	Service Time			
Minutes	Probability	Minutes	Probability		
2	0.15	1	0.10		
4	0.23	3	0.22		
6	0.35	5	0.35		
8	0.17	7	0.23		
10	0.10	9	0.10		

Random numbers (Start from North West corner and proceed along the row)

9371	1463	7214	1053	2164
8142	8707	9054	3866	1053
2924	1725	1185	6885	9980
5119	4086	3083	5217	7105

Q6 In a central railway station 15 computerized reservation counters are available. A customer can book his/her ticket in any train on any day in any one of these computerized reservation counters. The average time spent per customer by each clerk is 5 minutes. Average arrivals per hour during three types of activity periods have been calculated and customers have been surveyed to determine how long they are willing to wait during each type of period.

Type of period	Arrivals/hour	Customer's acceptable waiting time (minutes)
Peak	110	15
Normal	60	10
Low	30	5

Making suitable assumptions on this queueing process, determine how many counters should be kept open during each type of period.

Q7 In an election of M.L.A., two political parties A and B are thinking of nominating a candidate in a closed session, whose results are to be announced simultaneously. The following odds are offered for the various possible combinations of candidates.

Party A	Odds	Party B
SK	3:1	SG
SK	4:1	GI
SK	1:3	BJ
GL	3:7	SG
GL	3:2	GI
GL	1:4	BJ
KP	4:1	SG
KP	1:4	GI
KP	1:3	BJ

The parties want to select candidate in accordance with standard minimax criterion. What are the optimal strategies for party A and B?

Q8 Four types of items are under consideration for loading on a plane, with an unlimited supply of each type. The weights and values of various types are given below:

Item	Weight(tons)	Value
А	3	22
В	6	44
С	5	35
D	4	24

Determine as to which items should be loaded on the plane, and in what quantities, if the maximum capacity of the plane is 13 tons and the objective is to maximize the value of the shipment. Solve it by Dynamic programming.

- **Q9** Activities of a small project are given below.
 - a) Draw the network
 - b) What is the probability of completing the project within 26 days, within 28 days?

Activity	Pessimistic time (days)	Optimistic time (days)	Likely time (days)
1 - 2	1	1	1
2 - 3	7	1	4
2 - 4	10	8	12
3 - 5	7	3	5
4 - 5	1	1	1
5 - 6	9	3	6
5 - 7	8	4	6
6 - 8	12	4	8
7 - 8	8	2	5

Q10 A project details for normal, crash, time and cost is given in the table

A otivity (Norm	al	Crash		
ACTIVITY	Time (days)	Cost (₹)	Time (days)	Cost (₹)	
1 – 2	6	60	4	100	
1 – 3	4	60	2	200	
2 – 4	5	50	3	150	
2 – 5	3	45	1	65	
3 – 4	6	90	4	200	
4 – 6	8	80	4	300	
5 – 6	4	40	2	100	
6 – 7	3	45	2	80	

The indirect cost per day is ₹ 10.

- a) Draw the network and determine the critical path.
- b) Determine minimum total time and corresponding cost.

Z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
-3.9	.00005	.00005	.00004	.00004	.00004	.00004	.00004	.00004	.00003	.00003
-3.8	.00007	.00007	.00007	.00006	.00006	.00006	.00006	.00005	.00005	.00005
-3.7	.00011	.00010	.00010	.00010	.00009	.00009	.00008	.00008	.00008	.00008
-3.6	.00016	.00015	.00015	.00014	.00014	.00013	.00013	.00012	.00012	.00011
-3.5	.00023	.00022	.00022	.00021	.00020	.00019	.00019	.00018	.00017	.00017
-3.4	.00034	.00032	.00031	.00030	.00029	.00028	.00027	.00026	.00025	.00024
-3.3	.00048	.00047	.00045	.00043	.00042	.00040	.00039	.00038	.00036	.00035
-3.2	.00069	.00066	.00064	.00062	.00060	.00058	.00056	.00054	.00052	.00050
-3.1	.00097	.00094	.00090	.00087	.00084	.00082	.00079	.00076	.00074	.00071
-3.0	.00135	.00131	.00126	.00122	.00118	.00114	.00111	.00107	.00104	.00100
-2.9	.00187	.00181	.00175	.00169	.00164	.00159	.00154	.00149	.00144	.00139
-2.8	.00256	.00248	.00240	.00233	.00226	.00219	.00212	.00205	.00199	.00193
-2.7	.00347	.00336	.00326	.00317	.00307	.00298	.00289	.00280	.00272	.00264
-2.6	.00466	.00453	.00440	.00427	.00415	.00402	.00391	.00379	.00368	.00357
-2.5	.00621	.00604	.00587	.00570	.00554	.00539	.00523	.00508	.00494	.00480
-2.4	.00820	.00798	.00776	.00755	.00734	.00714	.00695	.00676	.00657	.00639
-2.3	.01072	.01044	.01017	.00990	.00964	.00939	.00914	.00889	.00866	.00842
-2.2	.01390	.01355	.01321	.01287	.01255	.01222	.01191	.01160	.01130	.01101
-2.1	.01786	.01743	.01700	.01659	.01618	.01578	.01539	.01500	.01463	.01426
-2.0	.02275	.02222	.02169	.02118	.02068	.02018	.01970	.01923	.01876	.01831
-1.9	.02872	.02807	.02743	.02680	.02619	.02559	.02500	.02442	.02385	.02330
-1.8	.03593	.03515	.03438	.03362	.03288	.03216	.03144	.03074	.03005	.02938
-1.7	.04457	.04363	.04272	.04182	.04093	.04006	.03920	.03836	.03754	.03673
-1.6	.05480	.05370	.05262	.05155	.05050	.04947	.04846	.04746	.04648	.04551
-1.5	.06681	.06552	.06426	.06301	.06178	.06057	.05938	.05821	.05705	.05592
-1.4	.08076	.07927	.07780	.07636	.07493	.07353	.07215	.07078	.06944	.06811
-1.3	.09680	.09510	.09342	.09176	.09012	.08851	.08691	.08534	.08379	.08226
-1.2	.11507	.11314	.11123	.10935	.10749	.10565	.10383	.10204	.10027	.09853
-1.1	.13567	.13350	.13136	.12924	.12714	.12507	.12302	.12100	.11900	.11702
-1.0	.15866	.15625	.15386	.15151	.14917	.14686	.14457	.14231	.14007	.13786
-0.9	.18406	.18141	.17879	.17619	.17361	.17106	.16853	.16602	.16354	.16109
-0.8	.21186	.20897	.20611	.20327	.20045	.19766	.19489	.19215	.18943	.18673
-0.7	.24196	.23885	.23576	.23270	.22965	.22663	.22363	.22065	.21770	.21476
-0.6	.27425	.27093	.26763	.26435	.26109	.25785	.25463	.25143	.24825	.24510
-0.5	.30854	.30503	.30153	.29806	.29460	.29116	.28774	.28434	.28096	.27760
-0.4	.34458	.34090	.33724	.33360	.32997	.32636	.32276	.31918	.31561	.31207
-0.3	.38209	.37828	.37448	.37070	.36693	.36317	.35942	.35569	.35197	.34827
-0.2	.42074	.41683	.41294	.40905	.40517	.40129	.39743	.39358	.38974	.38591
-0.1	.46017	.45620	.45224	.44828	.44433	.44038	.43644	.43251	.42858	.42465
-0.0	.50000	.49601	.49202	.48803	.48405	.48006	.47608	.47210	.46812	.46414

STANDARD NORMAL DISTRIBUTION: Table Values Represent AREA to the LEFT of the Z score.

Z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	.50000	.50399	.50798	.51197	.51595	.51994	.52392	.52790	.53188	.53586
0.1	.53983	.54380	.54776	.55172	.55567	.55962	.56356	.56749	.57142	.57535
0.2	.57926	.58317	.58706	.59095	.59483	.59871	.60257	.60642	.61026	.61409
0.3	.61791	.62172	.62552	.62930	.63307	.63683	.64058	.64431	.64803	.65173
0.4	.65542	.65910	.66276	.66640	.67003	.67364	.67724	.68082	.68439	.68793
0.5	.69146	.69497	.69847	.70194	.70540	.70884	.71226	.71566	.71904	.72240
0.6	.72575	.72907	.73237	.73565	.73891	.74215	.74537	.74857	.75175	.75490
0.7	.75804	.76115	.76424	.76730	.77035	.77337	.77637	.77935	.78230	.78524
0.8	.78814	.79103	.79389	.79673	.79955	.80234	.80511	.80785	.81057	.81327
0.9	.81594	.81859	.82121	.82381	.82639	.82894	.83147	.83398	.83646	.83891
1.0	.84134	.84375	.84614	.84849	.85083	.85314	.85543	.85769	.85993	.86214
1.1	.86433	.86650	.86864	.87076	.87286	.87493	.87698	.87900	.88100	.88298
1.2	.88493	.88686	.88877	.89065	.89251	.89435	.89617	.89796	.89973	.90147
1.3	.90320	.90490	.90658	.90824	.90988	.91149	.91309	.91466	.91621	.91774
1.4	.91924	.92073	.92220	.92364	.92507	.92647	.92785	.92922	.93056	.93189
1.5	.93319	.93448	.93574	.93699	.93822	.93943	.94062	.94179	.94295	.94408
1.6	.94520	.94630	.94738	.94845	.94950	.95053	.95154	.95254	.95352	.95449
1.7	.95543	.95637	.95728	.95818	.95907	.95994	.96080	.96164	.96246	.96327
1.8	.96407	.96485	.96562	.96638	.96712	.96784	.96856	.96926	.96995	.97062
1.9	.97128	.97193	.97257	.97320	.97381	.97441	.97500	.97558	.97615	.97670
2.0	.97725	.97778	.97831	.97882	.97932	.97982	.98030	.98077	.98124	.98169
2.1	.98214	.98257	.98300	.98341	.98382	.98422	.98461	.98500	.98537	.98574
2.2	.98610	.98645	.98679	.98713	.98745	.98778	.98809	.98840	.98870	.98899
2.3	.98928	.98956	.98983	.99010	.99036	.99061	.99086	.99111	.99134	.99158
2.4	.99180	.99202	.99224	.99245	.99266	.99286	.99305	.99324	.99343	.99361
2.5	.99379	.99396	.99413	.99430	.99446	.99461	.99477	.99492	.99506	.99520
2.6	.99534	.99547	.99560	.99573	.99585	.99598	.99609	.99621	.99632	.99643
2.7	.99653	.99664	.99674	.99683	.99693	.99702	.99711	.99720	.99728	.99736
2.8	.99744	.99752	.99760	.99767	.99774	.99781	.99788	.99795	.99801	.99807
2.9	.99813	.99819	.99825	.99831	.99836	.99841	.99846	.99851	.99856	.99861
3.0	.99865	.99869	.99874	.99878	.99882	.99886	.99889	.99893	.99896	.99900
3.1	.99903	.99906	.99910	.99913	.99916	.99918	.99921	.99924	.99926	.99929
3.2	.99931	.99934	.99936	.99938	.99940	.99942	.99944	.99946	.99948	.99950
3.3	.99952	.99953	.99955	.99957	.99958	.99960	.99961	.99962	.99964	.99965
3.4	.99966	.99968	.99969	.99970	.99971	.99972	.99973	.99974	.99975	.99976
3.5	.99977	.99978	.99978	.99979	.99980	.99981	.99981	.99982	.99983	.99983
3.6	.99984	.99985	.99985	.99986	.99986	.99987	.99987	.99988	.99988	.99989
3.7	.99989	.99990	.99990	.99990	.99991	.99991	.99992	.99992	.99992	.99992
3.8	.99993	.99993	.99993	.99994	.99994	.99994	.99994	.99995	.99995	.99995
3.9	.99995	.99995	.99996	.99996	.99996	.99996	.99996	.99996	.99997	.99997

STANDARD NORMAL DISTRIBUTION: Table Values Represent AREA to the LEFT of the Z score.