THE OPEN UNIVERSITY OF SRI LANKA
FACULTY OF ENGINEERING TECHNOLOGY
BACHELOR OF INDUSTRIAL STUDIES (INDUSTRIAL MANAGEMENT)
FINAL EXAMINATION -2006/2007
MEX4241- OPERATIONAL DECISION MAKING

DATE :28 MARCH 2007 (Wednesday)
TIME : 1330-1630 Hrs
DURATION : 3 HOURS

Instructions. *(i) Answer any five (05) questions. All questions carry equal marks.*
(ii) Normal distribution, Random Numbers and P_o values for multiple-server model tables are attached to the question paper.
(iii) Graph sheets will be provided at request.

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1. 1.1 "The various quantitative techniques used in Operational Research and elsewhere are often classified as being either deterministic or probabilistic in nature. In reality this is not a useful distinction because, in the final analysis, all management problems involve uncertainty and are, therefore, by definition, probabilistic". Discuss this statement.

(05 marks)

1.2 The operations manger of a factory assembling transformers has placed two rush orders for winding coils with two different suppliers, A and B. If neither deliver order arrives in 4 days, the assembly process must be shutdown until at least one of the orders arrives. The probability that supplier A can deliver winding coil in 4 days is 0.55. The probability that supplier B can deliver winding coil in 4 days is 0.35. Find the following.

(i) The probability that both suppliers deliver winding coils in 4 days. (since separate suppliers are involved, you can assume independence)

(ii) The probability that at least one supplier delivers winding coils in 4 days.

(iii) The probability that the assembly process is shut down in 4 days because of a shortage of winding coils.

(15 marks)

2. 2.1 What are the main features of the Normal Distribution?

(04 marks)

2.2 An assembly line contains 2,000 of a component which has a limited life. Records show that the life of the components is normally distributed with a mean of 900 hours and a standard deviation of 80 hours.

(i) What proportion of components will fail before 1,000 hours?

(ii) What proportion will fail before 750 hours?

(iii) What proportion of components fails between 850 and 650 hours?

(iv) Given that the standard deviation will remain at 80 hours what would be the average life have to be to ensure that not more than 10% components fail before 900 hours?

(16 marks)

3. 3.1 What is Linear Programming? Discuss its limitations.

(04marks)

3.2 A steel company is engaged in producing three different types of crankshafts A, B and C. These three different crankshafts are produced at the company's two different production capacities. In a normal 8-hour working day, Plant 1 produces 100, 200 and 200 crankshafts of type A, B and C respectively and Plant 2 produces 120, 120 and 400 crankshafts of type A, B and C respectively. The monthly demand of crankshaft A, B and C is 5,000, 6,000 and 14,000 units respectively. The daily cost of operation of plant 1 and plant 2 is Rs. 5,000.00 and Rs. 7,000.00 respectively.

Find the minimum number of days of operations per month at two different plants to minimize the total cost while meeting the demand. (Use graphical solution method.) *(16 marks)*

4. 4.1 What are the key steps in the simplex method in linear programming?

(03 marks)

4.2 Solve the following linear programming problem by simplex method.

Maximise $Z = 5X_1 + 3X_2 + 7X_3$

Subject to
$$X_1 + X_2 + 2X_3 \leq 22$$
$$3X_1 + 2X_2 + X_3 \leq 26$$
$$X_1 + X_2 + X_3 \leq 18$$
$$X_1, X_2, X_3 \geq 0$$

(12 marks)

4.3 Formulate the dual of above problem in part 4.2. *(05marks)*

5. 5.1 What is a typical transportation problem? In general, how do you decide which cost elements to include in a transportation problem?

(05 marks)

5.2 A departmental store wishes to purchase the following quantities of ladies dresses.

Dress size	I	II	III	IV
Quantity	100	200	450	150

Three manufactures are willing to supply dresses. The quantities given below are the maximum they are able to supply of any given combination of orders for dresses.

Manufacturer	A	B	C
Total Quantity	150	450	250

The departmental store expects profits per dress (in rupees) to vary with the manufacturer as given in table Q_5.

Manufacturer	Sizes			
	I	II	III	IV
A	2.50	4.00	5.00	2.00
B	3.00	3.50	5.50	1.50
C	2.00	4.50	4.50	2.50

Table Q_5

Using the transportation method, find how the orders should be placed with the manufacturers in order to maximise profits.

(15 marks)

6. 6.1 What are the different costs associated with inventory control systems?

(02 marks)

6.2 Explain a graphical method of determining Economic Order Quantity (EOQ) model.

(04 marks)

6.3 A Computer importer intends to apply an inventory control model to minimise the inventory costs for the year 2007. He has the following sales figures for the previous year.

Year	Sales (No. of Computers)
2003	3,145
2004	3,295
2005	3,445
2006	3,595

The fixed cost of a single procurement is Rs. 4,000.00 and the stock holding cost is Rs.200.00 per computer unit per year. A discount is available as described in table Q_6.

Order Quantity	Unit price with discount (Rs.)
1-499	3,000
500-999	2,900
1000 and over.	2,892

Table Q6

Determine

(i) Economic order quantity.
(ii) Corresponding average yearly cost.
(iii) Time between orders.

(14 marks)

7. 7.1 An ATM machine experiences random arrivals of 15 customers per hour and can handle 18 customers per hour. Assume that arrivals are poisson and that the service rate is exponentially distributed.

(i) What is the probability that there is no customer in service?
(ii) What is the average number of customers in line?
(iii) What is the average waiting time at the ATM?
(iv) How much time does the average customer wait before she gets her money?
(v) What is the probability that a customer has to wait?

(10 marks)

7.2 The particular bank wants to add an additional ATM machine to expedite their service. Determine the operation characteristics mentioned in part 7.1 after adding a new ATM.

(Note: Further information are available at the end of this question paper)

(10 marks)

8. Western province Emergency Rescue Squad knows from past experience that they will receive between zero and six emergency calls each night, according to the following discrete probability distribution.

Calls	Probability
0	0.05
1	0.12
2	0.15
3	0.25
4	0.22
5	0.15
6	0.06
	1.00

The rescue squad classifies each emergency call into one of three categories: minor, regular, or major emergency. The probability that a particular call will be each type of emergency is as follows.

Emergency Type	Probability
Minor	0.30
Regular	0.56
Major	0.14
	1.00

The type of emergency call determines the size of crew sent in response. A minor emergency requires a two-person crew; a regular call requires a three-person crew, and a major emergency requires a five-person crew.

Simulate the emergency calls received by the rescue squad for ten nights; compute the average number of each type of emergency calls per night, and determine the maximum number of crew members that might be needed on any given night.

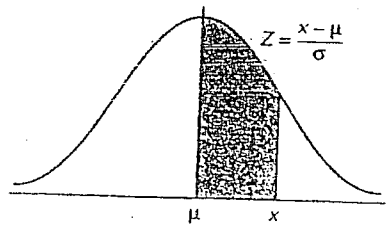
(20 marks)

END

DETAILS REQUIRED FOR QUESTION NO. 7

	Single Server Model	Multiple Server Model
Average number of customers in the queuing system	$L = \frac{\lambda}{\mu - \lambda}$	$L = \frac{\lambda\mu(\lambda/\mu)^s}{(s-1)!(s\mu-\lambda)^2} P_o + \frac{\lambda}{\mu}$
Average number of customers in the queue	$L_q = \frac{\lambda^2}{\mu(\mu-\lambda)}$	$L_q = L - \frac{\lambda}{\mu}$
Average time a customer spends in the queuing system	$W = \frac{1}{\mu - \lambda}$	$W = \frac{L}{\lambda}$
Average time a customer spends in the queue	$W_q = \frac{\lambda}{\mu(\mu-\lambda)}$	$W_q = W - \frac{1}{\mu}$

λ = mean arrival rate;
μ = mean service rate;
s = number of servers



ABLE Normal Curve Areas

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

TABLE Selected Values of P_0 for the Multiple-Server Model

$\rho = \lambda/s\mu$	Number of Channels: s									
ρ	2	3	4	5	6	7	8	9	10	15
0.02	0.96079	0.94177	0.92312	0.90484	0.88692	0.86936	0.85215	0.83527	0.81873	0.74082
0.04	0.92308	0.88692	0.85215	0.81873	0.78663	0.75578	0.72615	0.69768	0.67032	0.54881
0.06	0.88679	0.83526	0.78663	0.74082	0.69768	0.65705	0.61878	0.58275	0.54881	0.40657
0.08	0.85185	0.78659	0.72615	0.67032	0.61878	0.57121	0.52729	0.48675	0.44983	0.30119
0.10	0.81818	0.74074	0.67031	0.60653	0.54881	0.49659	0.44933	0.40657	0.36788	0.22313
0.12	0.78571	0.69753	0.61876	0.54881	0.48675	0.43171	0.38289	0.33960	0.30119	0.16530
0.14	0.75439	0.65679	0.57116	0.49657	0.43171	0.37531	0.72628	0.28365	0.24660	0.12246
0.16	0.72414	0.61838	0.52720	0.44931	0.38289	0.32628	0.27804	0.23693	0.20190	0.09072
0.18	0.69492	0.58214	0.48660	0.40653	0.33959	0.28365	0.23693	0.19790	0.16530	0.06721
0.20	0.66667	0.54795	0.44910	0.36782	0.30118	0.24659	0.20189	0.16530	0.13534	0.04979
0.22	0.63934	0.51567	0.41445	0.33277	0.26711	0.21437	0.17204	0.13807	0.11080	0.03688
0.24	0.61290	0.48519	0.38244	0.30105	0.23688	0.18636	0.14660	0.11532	0.09072	0.02732
0.26	0.58730	0.45640	0.35284	0.27233	0.21007	0.16200	0.12492	0.09632	0.07427	0.02024
0.28	0.56250	0.42918	0.32548	0.24633	0.18628	0.14082	0.10645	0.08045	0.06081	0.01500
0.30	0.53846	0.40346	0.30017	0.22277	0.16517	0.12241	0.09070	0.06720	0.04978	0.01111
0.32	0.51515	0.37913	0.27676	0.20144	0.14644	0.10639	0.07728	0.05612	0.04076	0.00823
0.34	0.49254	0.35610	0.25510	0.18211	0.12981	0.09247	0.06584	0.04687	0.03337	0.00610
0.36	0.47059	0.33431	0.23505	0.16460	0.11505	0.08035	0.05609	0.03915	0.02732	0.00452
0.38	0.44928	0.31367	0.21649	0.14872	0.10195	0.06981	0.04778	0.03269	0.02236	0.00335
0.40	0.42857	0.29412	0.19929	0.13433	0.09032	0.06065	0.04069	0.02729	0.01830	0.00248
0.42	0.40845	0.27559	0.18336	0.12128	0.07998	0.05267	0.03465	0.02279	0.01498	0.00184
0.44	0.38889	0.25802	0.16860	0.10944	0.07080	0.04573	0.02950	0.01902	0.01225	0.00136
0.46	0.36986	0.24135	0.15491	0.09870	0.06265	0.03968	0.02511	0.01587	0.01003	0.00101
0.48	0.35135	0.22554	0.14221	0.08895	0.05540	0.03442	0.02136	0.01324	0.00826	0.00075
0.50	0.33333	0.21053	0.13043	0.08010	0.04896	0.02984	0.01816	0.01104	0.00671	0.00055
0.52	0.31579	0.19627	0.11951	0.07207	0.04323	0.02586	0.01544	0.00920	0.00548	0.00041
0.54	0.29870	0.18273	0.10936	0.06477	0.03814	0.02239	0.01311	0.00767	0.00448	0.00030
0.56	0.28205	0.16986	0.09994	0.05814	0.03362	0.01936	0.01113	0.00638	0.00366	0.00022
0.58	0.26582	0.15762	0.09119	0.05212	0.02959	0.01673	0.00943	0.00531	0.00298	0.00017
0.60	0.25000	0.14599	0.08306	0.04665	0.02601	0.01443	0.00799	0.00441	0.00243	0.00012
0.62	0.23457	0.13491	0.07550	0.04167	0.02282	0.01243	0.00675	0.00366	0.00198	0.00009
0.64	0.21951	0.12438	0.06847	0.03715	0.01999	0.01069	0.00570	0.00303	0.00161	0.00007
0.66	0.20482	0.11435	0.06194	0.03304	0.01746	0.00918	0.00480	0.00251	0.00131	0.00005
0.68	0.19048	0.10479	0.05587	0.02930	0.01522	0.00786	0.00404	0.00207	0.00106	0.00004
0.70	0.17647	0.09569	0.05021	0.02590	0.01322	0.00670	0.00338	0.00170	0.00085	0.00003
0.72	0.16279	0.08702	0.04495	0.02280	0.01144	0.00570	0.00283	0.00140	0.00069	0.00002
0.74	0.14943	0.07875	0.04006	0.01999	0.00986	0.00483	0.00235	0.00114	0.00055	0.00001
0.76	0.13636	0.07087	0.03550	0.01743	0.00845	0.00407	0.00195	0.00093	0.00044	0.00001
0.78	0.12360	0.06335	0.03125	0.01510	0.00721	0.00341	0.00160	0.00075	0.00035	0.00001
0.80	0.11111	0.05618	0.02730	0.01299	0.00610	0.00284	0.00131	0.00060	0.00028	0.00001
0.82	0.09890	0.04933	0.02362	0.01106	0.00511	0.00234	0.00106	0.00048	0.00022	0.00000
0.84	0.08696	0.04280	0.02019	0.00931	0.00423	0.00190	0.00085	0.00038	0.00017	0.00000
0.86	0.07527	0.03656	0.01700	0.00772	0.00345	0.00153	0.00067	0.00029	0.00013	0.00000
0.88	0.06383	0.03060	0.01403	0.00627	0.00276	0.00120	0.00052	0.00022	0.00010	0.00000
0.90	0.05263	0.02491	0.01126	0.00496	0.00215	0.00092	0.00039	0.00017	0.00007	0.00000
0.92	0.04167	0.01947	0.00867	0.00377	0.00161	0.00068	0.00028	0.00012	0.00005	0.00000
0.94	0.03093	0.01427	0.00627	0.00268	0.00113	0.00047	0.00019	0.00008	0.00003	0.00000
0.96	0.02041	0.00930	0.00403	0.00170	0.00072	0.00029	0.00012	0.00005	0.00002	0.00000
0.98	0.01010	0.00454	0.00194	0.00081	0.00033	0.00013	0.00005	0.00002	0.00001	0.00000

Table 8-3 Random Numbers

39 65 76 45 45	19 90 69 64 61	20 26 36 31 62	58 24 97 14 97	95 06 70 99 00
73 71 23 70 90	65 97 60 12 11	31 56 34 19 19	47 83 75 51 33	30 62 38 20 46
72 20 47 33 84	51 67 47 97 19	98 40 07 17 66	23 05 09 51 80	59 78 11 52 49
75 17 25 69 17	17 95 21 78 58	24 33 45 77 48	69 81 84 09 29	93 22 70 45 80
37 48 79 88 74	63 52 06 34 30	01 31 60 10 27	35 07 79 71 53	28 99 52 01 41
02 89 08 16 94	85 53 83 29 95	56 27 09 24 43	21 78 55 09 82	72 61 88 73 61
87 18 15 70 07	37 79 49 12 38	48 13 93 55 96	41 92 45 71 51	09 18 25 58 94
98 83 71 70 15	89 09 39 59 24	00 06 41 41 20	14 36 59 25 47	54 45 17 24 89
10 09 58 07 04	76 62 16 48 68	58 76 17 14 86	59 53 11 52 2	66 04 18 72 87
47 90 56 37 31	71 82 13 50 41	27 55 10 24 92	28 04 67 53 44	95 23 00 84 47
93 05 31 03 07	34 18 04 52 35	74 13 39 35 22	68 95 23 92 35	36 63 70 35 33
21 89 11 47 99	11 20 99 45 18	76 51 94 84 86	13 79 93 37 55	98 16 04 41 67
95 18 94 06 97	27 37 83 28 71	79 57 95 13 91	09 61 87 25 21	56 20 11 32 44
97 08 31 55 73	10 65 81 92 59	77 31 61 95 46	20 44 90 32 64	26 99 76 75 63
69 26 88 86 13	59 71 74 17 32	48 38 75 93 29	73 37 32 04 05	60 82 29 20 25
41 47 10 25 03	87 63 93 95 17	81 83 83 04 49	77 45 85 50 51	79 88 01 97 30
91 94 14 63 62	08 61 74 51 69	92 79 43 89 79	29 18 94 51 23	14 85 11 47 23
80 06 54 18 47	08 52 85 08 40	48 40 35 94 22	72 65 71 08 86	50 03 42 99 36
67 72 77 63 99	89 85 84 46 06	64 71 06 21 66	89 37 20 70 01	61 65 70 22 12
59 40 24 13 75	42 29 72 23 19	06 94 76 10 08	81 30 15 39 14	81 83 17 16 33
63 62 06 34 41	79 53 36 02 95	94 61 09 43 62	20 21 14 68 86	84 95 48 46 45
78 47 23 53 90	79 93 96 38 63	34 85 52 05 09	85 43 01 72 73	14 93 87 81 40
87 68 62 15 43	97 48 72 66 48	53 16 71 13 81	59 97 50 99 52	24 62 20 42 31
47 60 92 10 77	26 97 05 73 51	88 46 38 03 58	72 68 49 29 31	75 70 16 08 24
56 88 87 59 41	06 87 37 78 48	65 88 69 58 39	88 02 84 27 83	85 81 56 39 38
22 17 68 65 84	87 02 22 57 51	68 69 80 95 44	11 29 01 95 80	49 34 35 86 47
19 36 27 59 46	39 77 32 77 09	79 57 92 36 59	89 74 19 82 15	08 58 94 34 74
16 77 23 02 77	28 06 24 25 93	22 45 44 84 11	87 80 61 65 31	09 71 91 74 25
78 43 76 71 61	97 67 63 99 61	80 45 67 93 82	59 73 19 85 23	53 33 65 97 21
03 28 28 26 08	69 30 16 09 05	53 58 47 70 93	66 56 45 65 79	45 56 20 19 47
04 31 17 21 56	33 73 99 19 87	26 72 39 27 67	53 77 57 68 93	60 61 97 22 61
61 06 98 03 91	87 14 77 43 96	43 00 65 98 50	45 60 33 01 07	98 99 46 50 47
23 68 35 26 00	99 53 93 61 28	52 70 05 48 34	56 65 05 61 86	90 92 10 70 80
15 39 25 70 99	93 86 52 77 65	15 33 59 05 28	22 87 26 07 47	86 96 98 29 06
58 71 96 30 24	18 46 23 34 27	85 13 99 24 44	49 18 09 79 49	74 16 32 23 02
93 22 53 64 39	07 10 63 76 35	87 03 04 79 88	08 13 13 85 51	55 34 57 72 69
78 76 58 54 74	92 38 70 96 92	52 06 79 79 45	82 63 18 27 44	69 66 92 19 09
61 81 31 96 82	00 57 25 60 59	46 72 60 18 77	55 66 12 62 11	08 99 55 64 57
42 88 07 10 05	24 98 65 63 21	47 21 61 88 32	27 80 30 21 60	10 92 35 36 12
77 94 30 05 39	28 10 99 00 27	12 73 73 99 12	49 99 57 94 82	96 88 57 17 91