



**Institute of Human Resource Advancement (IHRA)
University of Colombo, Sri Lanka**

**Master of Science in Service Management Course No.06
1st Trimester Examination**

(Held in August, 2020)

MSM 5131 – Quantitative Techniques for Service Management

Instructions to the Candidates

- (1) This paper consists six (06) questions and six (06) pages.
- (2) Standard tables, formula sheets are provided
- (3) Answer only five (05) questions.
- (4) Write your Index Number on all pages of answer scripts.
- (5) Time allocated for the examination is Three (03) hours.
- (6) Tie up all answer sheets at the end of the examination.
- (7) If a page or a part of this question paper is not printed, please inform the Supervisor immediately.

- 1 i. It is expected to determine the daily usage of teller machine on average by the customers. A study has been carried out during the last 60 days and results indicated that 85.2 customers on average used the teller machine with a standard deviation of 6.2. Estimate the average usage of teller machine at 95% confidence.

(06 Marks)

- ii. When a sample size of 5000 employees is analyzed, there are three thousand five hundred employees with high educational qualifications. Estimate the proportion of the total employees with high educational qualifications at 95% confidence.

(06 Marks)

- iii. There was a study to estimate the difference of weights between two products produced by two companies. Following information is provided for the two products.

	Company 1	Company 2
Average weight	60.5Kg	56.2Kg
Standard deviation	1.4Kg	1.5Kg
Sample size	120	100

Estimate the difference of average weight between the two products produced by the two companies at 95% confidence.

(08 Marks)

(Total 20marks)

2. i. A businessman says that the average weight of his product is 40kg. A sample of size 50 is selected to study this statement. According to the results, the average weight is 38kg with the standard deviation of 4.3kg. Test the statement at 95% confidence.

(06 Marks)

- ii. A machine producer says that there is no difference between the quality of machine 1 and machine 2. When a sample size of 200 items produced by machine 1 is tested, the level of quality is 93% and another sample size of 250 items produced by machine 2 is tested, the level of quality is 91 %. Test the producer's statement at 95% level of confidence.

(06 Marks)

- iii. Management of three companies says that there is no difference between their products in relation to durability. Three samples have been selected and their durability in months has been estimated. Results are given in the following table. Test whether there is a significant difference between the durability of the products of at least two companies.

Sample 1	sample 2	sample 3
4	5	6
5	6	7
3	5	7
5	6	5
3	3	5

(08 Marks)

(Total 20marks)

3. Following table is providing information relative to price and supply of a transport service in hours.

Price	Supply (Hours)
4	30
5	40
6	60
6	60
7	80
8	90

- i. Compute the coefficient of correlation and identify the association between price and supply.

(04 Marks)

- ii. Construct the Simple regression model.

(06 Marks)

- iii. Construct the Regression ANOVA table and interpret the results.

(06 Marks)

- iv. Calculate, R-square and adjusted R-square values and interpret the results.

(04 Marks)

(Total 20 marks)

4. i. A food manufacturing company mixes three components to produce three special food items. These components are component 1, component 2 and component 3. Special food items are named as category "A", category "B" and category "C". Management wishes to determine the optimal mix of the three components that will maximize profit. The available maximum quantities of each component and the cost per kilogram are as follows.

Component	Maximum kilogram	Cost of a Kilogram
1	500	60
2	350	70
3	460	55

In order to ensure the proper mix of these components, specifications have been determined. The components mix and as well as selling price of each food item are given below.

Food Category	Component specifications	Selling price of a Kg
A	Not less than 30% of 1	350
	Not more than 40% of 2	
	Not less than 20% of 3	
B	Not less than 40% of 3	300
C	Not less than 20% of 1	200
	Not more than 30% of 2	

Develop the LP model.

(10 Marks)

ii. $Max Z = 50X_1 + 40X_2$ (Income)

St. $3X_1 + 2X_2 \leq 60$ Raw Materials

$2X_1 + 3X_2 \leq 60$ Labor

$X_1 \leq 15$ Ware house space for X_1

$X_1, X_2 \geq 0$

Find the optimum solution using the graphical method.

(10 Marks)

(Total 20 marks)

5. A company produces three products: P, Q and R. Following simplex table provides the optimum solution for the given LP model.

$Max Z = 8X_1 + 9X_2 + 11X_3$ (income)

St. $3X_1 + 4X_2 + 3X_3 \leq 260$ (resource 1)

$4X_1 + 3X_2 + 5X_3 \leq 220$ (resource 2)

$2X_1 + 2X_2 + 2X_3 \leq 100$ (resource 3)

$X_1, X_2, X_3 \geq 0$

cb \ Cj	basis	solution	8	9	11	0	0	0
			X1	X2	X3	S1	S2	S3
0	S1	95	-1/2	0	0	1	1/2	-11/4
11	X3	35	1/2	0	1	0	1/2	-3/4
9	X2	15	1/2	1	0	0	-1/2	5/4
	Zj	520	10	9	11	0	1	3
	Cj-zj		-2	0	0	0	-1	-3

- Why product "P" is not produced?
(04 Marks)
 - What are the marginal prices of resources 2 and 3?
(04 Marks)
 - Find the upper and lower limits of Q product.
(04 Marks)
 - Find the upper and lower limits of resource 2.
(04 Marks)
 - Management of the company is willing to introduce a new product "S" that needs 3 unit of resource one, 2 units of resource two and 3 units of resource three. The selling price of the product is Rs.12. Advice the management on new product.
(04 Marks)
- (Total 20 marks)**

6. It is expected to transport employees from three areas to three factories to fill the labor demand. The capacity of the areas and the labor demand of factories are provided below.

Areas	Capacity	Factories	Demand
A	100	P	200
B	200	Q	150
C	300	R	250

Transportation cost of an employee from each area to factory is provided in the following table.

Areas	Factories (Cost Rs.)		
	P	Q	R
A	18	5	4
B	5	8	15
C	3	12	10

- i. Find the initial solution using Vogel's Approximation Method (VAM) or Least cost cell method.

(10 Marks)

- ii. Find the optimal transportation schedule.

(10 Marks)

(Total 20 marks)

Formula sheet

$$\text{Mean} = \frac{\sum x}{n}$$

$$\text{Variance} = \frac{\sum (x - \bar{x})^2}{n-1}$$

$$(\bar{x}) \pm z_{\frac{\alpha}{2}} SE \quad SE = \frac{\sigma}{\sqrt{n}} \quad SE = \sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}} \quad SE = SP \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}$$

$$(\bar{x}_1 - \bar{x}_2) \pm z_{\frac{\alpha}{2}} SE \quad SP = \sqrt{\frac{(n_1-1)s_1^2 + (n_2-1)s_2^2}{n_1+n_2-2}}$$

$$p \pm z_{\frac{\alpha}{2}} SE \quad p_1 - p_2 \pm z_{\frac{\alpha}{2}} SE \quad TS = \frac{\bar{x} - \mu_0}{\frac{\sigma}{\sqrt{n}}}$$

$$TS = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}} \quad TS = \frac{\bar{x}_1 - \bar{x}_2}{SP \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}} \quad TS = \frac{p_1 - p_2}{\sqrt{\frac{p_1 q_1}{n_1} + \frac{p_2 q_2}{n_2}}}$$

$$SST = \sum (x - \bar{\bar{x}})^2 \quad SSB = \sum (\bar{x} - \bar{\bar{x}})^2 \quad SSW = \sum (x - \bar{x})^2$$

$$\text{Coefficient of Correlation} = \frac{n \sum xy - \sum x \sum y}{\sqrt{(n \sum x^2 - (\sum x)^2)(n \sum y^2 - (\sum y)^2)}}$$

Normal Equations

$$Y = a + bx$$

$$\sum y = na + b \sum x$$

$$\sum xy = a \sum x + b \sum x^2$$

$$\text{Sum of Square of Regression} = \sum (\hat{Y} - \bar{Y})^2$$

$$\text{Sum of Square of Residual} = \sum (Y - \hat{Y})^2$$

$$\text{Sum of Square of Total} = \sum (Y - \bar{Y})^2$$

$$R^2 = \frac{\sum (\hat{Y} - \bar{Y})^2}{\sum (Y - \bar{Y})^2} \quad \bar{R}^2 = 1 - (1 - R^2) \frac{n - 1}{n - k - 1}$$

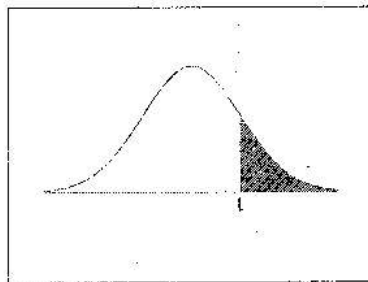
$$\text{Upper limit} \quad \text{Min} \left(ck + \frac{cj - zj}{akj} \right) \text{ for all } akj < 0$$

$$\text{Lower limit} \quad \text{Max} \left(ck + \frac{cj - zj}{akj} \right) \text{ for all } akj > 0$$

$$\text{Upper limit} \quad \text{Min} \left(bi - \frac{bk}{akj} \right) \text{ for all } akj < 0$$

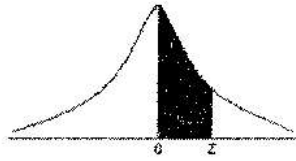
$$\text{Lower limit} \quad \text{Max} \left(bi - \frac{bk}{akj} \right) \text{ for all } akj > 0$$

t-Distribution Table



The shaded area is equal to α for $t = t_{\alpha}$.

df	$t_{.100}$	$t_{.050}$	$t_{.025}$	$t_{.010}$	$t_{.005}$
1	3.078	6.314	12.706	31.821	63.657
2	1.886	2.920	4.303	6.965	9.925
3	1.638	2.353	3.182	4.541	5.841
4	1.533	2.132	2.776	3.747	4.604
5	1.476	2.015	2.571	3.365	4.032
6	1.440	1.943	2.447	3.143	3.707
7	1.415	1.895	2.365	2.998	3.499
8	1.397	1.860	2.306	2.896	3.355
9	1.383	1.833	2.262	2.821	3.250
10	1.372	1.812	2.228	2.764	3.169
11	1.363	1.796	2.201	2.718	3.106
12	1.356	1.782	2.179	2.681	3.055
13	1.350	1.771	2.160	2.650	3.012
14	1.345	1.761	2.145	2.624	2.977
15	1.341	1.753	2.131	2.602	2.947
16	1.337	1.746	2.120	2.583	2.921
17	1.333	1.740	2.110	2.567	2.898
18	1.330	1.734	2.101	2.552	2.878
19	1.328	1.729	2.093	2.539	2.861
20	1.325	1.725	2.086	2.528	2.845
21	1.323	1.721	2.080	2.518	2.831
22	1.321	1.717	2.074	2.508	2.819
23	1.319	1.714	2.069	2.500	2.807
24	1.318	1.711	2.064	2.492	2.797
25	1.316	1.708	2.060	2.485	2.787
26	1.315	1.706	2.056	2.479	2.779
27	1.314	1.703	2.052	2.473	2.771
28	1.313	1.701	2.048	2.467	2.763
29	1.311	1.699	2.045	2.462	2.756
30	1.310	1.697	2.042	2.457	2.750
32	1.309	1.694	2.037	2.449	2.738
34	1.307	1.691	2.032	2.441	2.728
36	1.306	1.688	2.028	2.434	2.719
38	1.304	1.686	2.024	2.429	2.712
∞	1.282	1.645	1.960	2.326	2.576



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	0.49865	0.49869	0.49874	0.49878	0.49882	0.49886	0.49889	0.49893	0.49896	0.49900
3.1	0.49903	0.49906	0.49910	0.49913	0.49916	0.49918	0.49921	0.49924	0.49926	0.49929
3.2	0.49931	0.49934	0.49936	0.49938	0.49940	0.49942	0.49944	0.49946	0.49948	0.49950
3.3	0.49952	0.49953	0.49955	0.49957	0.49958	0.49960	0.49961	0.49962	0.49964	0.49965
3.4	0.49966	0.49968	0.49969	0.49970	0.49971	0.49972	0.49973	0.49974	0.49975	0.49976
3.5	0.49977	0.49978	0.49978	0.49979	0.49980	0.49981	0.49981	0.49982	0.49983	0.49983

CRITICAL VALUES for the "F" Distribution, ALPHA = .05.

Denominator DF	Numerator DF									
	1	2	3	4	5	6	7	8	9	10
1	161.448	199.500	215.707	224.583	230.162	233.986	236.768	238.883	240.543	241.882
2	18.513	19.000	19.164	19.247	19.296	19.330	19.353	19.371	19.385	19.396
3	10.128	9.552	9.277	9.117	9.013	8.941	8.887	8.845	8.812	8.786
4	7.709	6.944	6.591	6.388	6.256	6.163	6.094	6.041	5.999	5.964
5	6.608	5.786	5.409	5.192	5.050	4.950	4.876	4.818	4.772	4.735
6	5.987	5.143	4.757	4.534	4.387	4.284	4.207	4.147	4.099	4.060
7	5.591	4.737	4.347	4.120	3.972	3.866	3.787	3.726	3.677	3.637
8	5.318	4.459	4.066	3.838	3.687	3.581	3.500	3.438	3.388	3.347
9	5.117	4.256	3.863	3.633	3.482	3.374	3.293	3.230	3.179	3.137
10	4.965	4.103	3.708	3.478	3.326	3.217	3.135	3.072	3.020	2.978
11	4.844	3.982	3.587	3.357	3.204	3.095	3.012	2.948	2.896	2.854
12	4.747	3.885	3.490	3.259	3.106	2.996	2.913	2.849	2.796	2.753
13	4.667	3.806	3.411	3.179	3.025	2.915	2.832	2.767	2.714	2.671
14	4.600	3.739	3.344	3.112	2.958	2.848	2.764	2.699	2.646	2.602
15	4.543	3.682	3.287	3.056	2.901	2.790	2.707	2.641	2.588	2.544
16	4.494	3.634	3.239	3.007	2.852	2.741	2.657	2.591	2.538	2.494
17	4.451	3.592	3.197	2.965	2.810	2.699	2.614	2.548	2.494	2.450
18	4.414	3.555	3.160	2.928	2.773	2.661	2.577	2.510	2.456	2.412
19	4.381	3.522	3.127	2.895	2.740	2.628	2.544	2.477	2.423	2.378
20	4.351	3.493	3.098	2.866	2.711	2.599	2.514	2.447	2.393	2.348
21	4.325	3.467	3.072	2.840	2.685	2.573	2.488	2.420	2.366	2.321
22	4.301	3.443	3.049	2.817	2.661	2.549	2.464	2.397	2.342	2.297
23	4.279	3.422	3.028	2.796	2.640	2.528	2.442	2.375	2.320	2.275
24	4.260	3.403	3.009	2.776	2.621	2.508	2.423	2.355	2.300	2.255
25	4.242	3.385	2.991	2.759	2.603	2.490	2.405	2.337	2.282	2.236
26	4.225	3.369	2.975	2.743	2.587	2.474	2.388	2.321	2.265	2.220
27	4.210	3.354	2.960	2.728	2.572	2.459	2.373	2.305	2.250	2.204
28	4.196	3.340	2.947	2.714	2.558	2.445	2.359	2.291	2.236	2.190
29	4.183	3.328	2.934	2.701	2.545	2.432	2.346	2.278	2.223	2.177
30	4.171	3.316	2.922	2.690	2.534	2.421	2.334	2.266	2.211	2.165
31	4.160	3.305	2.911	2.679	2.523	2.409	2.323	2.255	2.199	2.153
32	4.149	3.295	2.901	2.668	2.512	2.399	2.313	2.244	2.189	2.142
33	4.139	3.285	2.892	2.659	2.503	2.389	2.303	2.235	2.179	2.133
34	4.130	3.276	2.883	2.650	2.494	2.380	2.294	2.225	2.170	2.123
35	4.121	3.267	2.874	2.641	2.485	2.372	2.285	2.217	2.161	2.114
36	4.113	3.259	2.866	2.634	2.477	2.364	2.277	2.209	2.153	2.106
37	4.105	3.252	2.859	2.626	2.470	2.356	2.270	2.201	2.145	2.098
38	4.098	3.245	2.852	2.619	2.463	2.349	2.262	2.194	2.138	2.091
39	4.091	3.238	2.845	2.612	2.456	2.342	2.255	2.187	2.131	2.084
40	4.085	3.232	2.839	2.606	2.449	2.336	2.249	2.180	2.124	2.077
41	4.079	3.226	2.833	2.600	2.443	2.330	2.243	2.174	2.118	2.071
42	4.073	3.220	2.827	2.594	2.438	2.324	2.237	2.168	2.112	2.065
43	4.067	3.214	2.822	2.589	2.432	2.318	2.232	2.163	2.106	2.059
44	4.062	3.209	2.816	2.584	2.427	2.313	2.226	2.157	2.101	2.054
45	4.057	3.204	2.812	2.579	2.422	2.308	2.221	2.152	2.096	2.049
46	4.052	3.200	2.807	2.574	2.417	2.304	2.216	2.147	2.091	2.044
47	4.047	3.195	2.802	2.570	2.413	2.299	2.212	2.143	2.086	2.039
48	4.043	3.191	2.798	2.565	2.409	2.295	2.207	2.138	2.082	2.035
49	4.038	3.187	2.794	2.561	2.404	2.290	2.203	2.134	2.077	2.030
50	4.034	3.183	2.790	2.557	2.400	2.286	2.199	2.130	2.073	2.026