UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2019/2020

COURSE NAME : CIVIL ENGINEERING STATISTICS
COURSE CODE : BFC 34303
PROGRAMME CODE : BFF
EXAMINATION DATE : DECEMBER 2019 / JANUARY 2020
DURATION : 3 HOURS
INSTRUCTION : ANSWER **ALL** QUESTIONS

THIS QUESTION PAPER CONSISTS OF **FOURTEEN (14)** PAGES

Q1 A structural engineer is studying the compressive strength of concrete. He takes a random sample (n) of 10 concrete specimens that has a mean compressive strength ($\bar{X}$) of 2850 psi and standard deviation (s) of 330 psi. Correspondently, he hypothesised that the mean compressive strength of most concrete (μ_o) will be more than 2,500 psi. Using the significance level (α) of 0.05 and assuming that the data is normally distributed, test his hypothesis accordingly;

(a) State the null hypothesis and alternative hypothesis.

(4 mark)

(b) Suggest whether to use a one-tailed test or a two-tailed test. Provide a sketch.

(4 marks)

(c) Decide on which test statistic to be used, either the *z*-test or *t*-test statistic. Give reasons for your decision.

(4 marks)

(d) Determine the critical value and specify the criteria for rejection of the null hypothesis.

(6 marks)

(e) Calculate the test statistic and decide whether to reject or accept the null hypothesis. Provide a conclusion based on the result of this hypothesis testing.

(7 marks)

Q2 Road lighting has significant road safety benefits. A researcher is attempting to investigate the relationship between road safety and road lighting. She believes that increased luminance of road lighting can reduce road accidents. She gathers night to day crash ratio and average luminance data for seven roads (see **Table Q2**) to find a relationship between the two variables.

(a) State the dependent variable (Y) and independent variable (X).

(2 mark)

(b) Using simple linear regression, calculate the slope (b) and intercept (a).

(12 marks)

(c) Write down the equation that relates variables Y and X.

(2 marks)

(d) Determine the coefficient of correlation (r) and comment on the value.

(5 marks)

(e) Determine the coefficient of determination (R^2) and comment on the value.

(4 marks)

Q3 (a) **Table Q3(a)** shows the stiffness modulus of asphalt binder obtained from the two different methods. Using a significance level of 0.1, determine if there is a difference between the mean stiffness modulus obtained using the two different methods.

(12 marks)

(b) The random variable, X represents the time (in hours) spent by civil engineers working on-site per week. It has a probability distribution shown in **Table Q3(b)**. By applying the central limit theorem, calculate the probability that the average time spent working on-site per week by a population of 42 civil engineers will be less than 6.5 hours.

(13 marks)

Q4 An e-hailing company, A, has three competitors which are B, C, and D. Company A hires a transport e-hailing consultant to determine if the percentage of riders who prefer each of the four services is the same. A survey of 910 randomly selected riders is conducted. **Table Q4** shows the results of the survey.

The following are the null (H_o) and alternative (H_a) hypotheses:

H_o : The population frequencies are equal to the expected frequencies.
H_a : The population frequencies are unequal to the expected frequencies

Using Chi-square test at a significance level of 0.05, determine if there is enough evidence to conclude that the proportions are really the same.

(25 marks)

– END OF QUESTIONS –

FINAL EXAMINATION

SEMESTER/SESSION : SEM I / 2019/2020
COURSE NAME : CIVIL ENGINEERING STATISTICS
PROGRAMME CODE : BFF
COURSE CODE : BFC 34303

TABLE Q2: Night to day crash ratio and average luminance for reported accidents on seven difference roads

Night/Day Crash Ratio	**Average Luminance (cd/m^2)**
0.41	0.27
0.32	0.52
0.35	0.83
0.29	1.12
0.31	1.30
0.23	1.58
0.21	1.81

Note: cd/m2 is candela per square meter, the SI unit of luminance, which is the photometric measure of luminous intensity per unit area of light travelling in a given direction

TABLE Q3(a): Asphalt stiffness modulus

Sample A (kPa)	**Sample B (kPa)**
1.45	2.33
1.12	1.97
1.32	1.37
1.22	1.72
1.0	1.22
2.1	1.52

TABLE Q3(b): Probability distribution of X

x	6	7	8	9
$P(X=x)$	0.4	0.3	0.2	0.1

TABLE Q4: Results of the survey for e-hailing services

E-hailing company	**A**	**B**	**C**	**D**
Number of Riders	262	234	204	210

FINAL EXAMINATION

SEMESTER/SESSION : SEM I / 2019/2020
COURSE NAME : CIVIL ENGINEERING STATISTICS
PROGRAMME CODE : BFF
COURSE CODE : BFC 34303

APPENDIX A: STATISTICAL FORMULAS

The following information may be useful. The symbols have their usual meaning.

Mean and Variance of Ungrouped Data

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

Mean and Variance of Grouped Data

$$\bar{x} = \frac{\sum fx}{\sum f} \qquad s^2 = \frac{\sum fx^2 - \frac{(\sum fx)^2}{\sum f}}{(\sum f) - 1}$$

Standard Normal Distribution z-value

$$z = \frac{X - \mu}{\sigma}$$

Central Limit Theorem

$$\mu_{\bar{X}} = \mu \qquad \sigma_{\bar{X}} = \frac{\sigma}{\sqrt{n}} \qquad z = \frac{\bar{X} - \mu}{\left(\frac{\sigma}{\sqrt{n}}\right)}$$

$$\mu = E(X) = \sum x.P(X) \qquad \sigma = Std(X) = \sqrt{E(X^2) - [E(X)]^2} \qquad E(X^2) = \sum x^2.P(X)$$

Difference Between Two Means

$$Z = \bar{X} - \bar{Y} \qquad \mu_{\bar{X}-\bar{Y}} = \mu_{\bar{X}} - \mu_{\bar{Y}} \qquad \sigma_{\bar{X}-\bar{Y}} = \sqrt{\frac{{\sigma_X}^2}{n} + \frac{{\sigma_Y}^2}{m}}$$

FINAL EXAMINATION

SEMESTER/SESSION : SEM I / 2019/2020
COURSE NAME : CIVIL ENGINEERING STATISTICS
PROGRAMME CODE : BFF
COURSE CODE : BFC 34303

Confidence Interval

$$\bar{X} \pm z\frac{s}{\sqrt{n}} \qquad \bar{X} \pm t\frac{s}{\sqrt{n}} \qquad t = \frac{\bar{X}-\mu}{s/\sqrt{n}}$$

$$p \pm z\sqrt{\frac{p(1-p)}{n}} \qquad FPC = \sqrt{\frac{N-n}{N-1}} \qquad \bar{X} \pm z\frac{s}{\sqrt{n}}\sqrt{\frac{N-n}{N-1}}$$

$$(\mu_{\bar{X}} - \mu_{\bar{Y}}) \pm t_{\frac{\alpha}{2},df}\left(\sqrt{\frac{{s_{\bar{X}}}^2}{n}+\frac{{s_{\bar{Y}}}^2}{m}}\right) \qquad df = \frac{\left(\frac{{s_{\bar{X}}}^2}{n}+\frac{{s_{\bar{Y}}}^2}{m}\right)^2}{\frac{\left(\frac{{s_{\bar{X}}}^2}{n}\right)^2}{n-1}+\frac{\left(\frac{{s_{\bar{Y}}}^2}{m}\right)^2}{m-1}}$$

One-Sample Hypothesis Testing (z-Test and t-Test)

$$z = \frac{\bar{X}-\mu_o}{\sigma/\sqrt{n}} \qquad z = \frac{\bar{X}-\mu_o}{s/\sqrt{n}} \qquad t = \frac{\bar{X}-\mu_o}{s/\sqrt{n}}$$

Two-Sample Hypothesis Testing (z-Test and t-Test)

$$z = \frac{\bar{X}_X-\bar{X}_Y}{\sqrt{\frac{{s_X}^2}{n}+\frac{{s_Y}^2}{m}}} \qquad t = \frac{\bar{X}_X-\bar{X}_Y}{\sqrt{\frac{{s_P}^2}{n}+\frac{{s_P}^2}{m}}} \qquad {s_P}^2 = \frac{(n-1){s_X}^2+(m-1){s_Y}^2}{n+m-2}$$

Simple Linear Regression

$$Y = a + bX \qquad a = \frac{\sum Y}{n} - b\frac{\sum X}{n} \qquad e = Y - \hat{Y}$$

$$b = \frac{n(\sum XY) - (\sum X)(\sum Y)}{n(\sum X^2) - (\sum X)^2} \qquad r = \frac{n(\sum XY) - (\sum X)(\sum Y)}{\sqrt{[n(\sum X^2) - (\sum X)^2][n(\sum Y^2) - (\sum Y)^2]}}$$

$$s_{y.x} = \sqrt{\frac{\sum Y^2 - a(\sum Y) - b(\sum XY)}{n-2}}$$

FINAL EXAMINATION

SEMESTER/SESSION : SEM I / 2019/2020
COURSE NAME : CIVIL ENGINEERING STATISTICS
PROGRAMME CODE : BFF
COURSE CODE : BFC 34303

F-Test

$$F = \frac{{s_1}^2}{{s_2}^2} \qquad v_1 = n_1 - 1 \qquad v_2 = n_2 - 1$$

One Way ANOVA Test

$$SS = \sum X^2 - \frac{(\sum X)^2}{n} \qquad SST = \sum\left(\frac{{T_c}^2}{n_c}\right) - \frac{(\sum X)^2}{n} \qquad SSE = SS - SST$$

$$MST = \frac{SST}{k-1} \qquad MSE = \frac{SSE}{n-k} \qquad F = \frac{MST}{MSE}$$

$$v_1 = k - 1 \qquad v_2 = n - k$$

Chi-Square Test

$$\chi^2 = \frac{(n-1)s^2}{\sigma^2} \qquad df = n - 1$$

Chi-Square Goodness of Fit Test

$$\chi^2 = \sum\left[\frac{(f_o - f_e)^2}{f_e}\right] \qquad df = k - 1$$

Chi-Square Contingency Table Analysis

$$\chi^2 = \sum\left[\frac{(f_o - f_e)^2}{f_e}\right] \qquad df = (r-1)(c-1)$$

Mann-Whitney Test

$$z = \frac{W - \frac{n_1(n_1 + n_2 + 1)}{2}}{\sqrt{\frac{n_1 n_2 (n_1 + n_2 + 1)}{12}}}$$

Mann-Whitney U Test

$$U_1 = n_1 n_2 + \frac{n_1(n_1 + 1)}{2} - R_1 \qquad U_2 = n_1 n_2 + \frac{n_2(n_2 + 1)}{2} - R_2$$

FINAL EXAMINATION

SEMESTER/SESSION	: SEM I / 2019/2020	PROGRAMME CODE	: BFF
COURSE NAME	: CIVIL ENGINEERING STATISTICS	COURSE CODE	: BFC 34303

APPENDIX B: STATISTICAL TABLES

I. Standard Normal Distribution (Right-Tail) showing P (Z > z)

z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.5000	0.4960	0.4920	0.4880	0.4840	0.4801	0.4761	0.4721	0.4681	0.4641
0.1	0.4602	0.4562	0.4522	0.4483	0.4443	0.4404	0.4364	0.4325	0.4286	0.4247
0.2	0.4207	0.4168	0.4129	0.4090	0.4052	0.4013	0.3974	0.3936	0.3897	0.3859
0.3	0.3821	0.3783	0.3745	0.3707	0.3669	0.3632	0.3594	0.3557	0.3520	0.3483
0.4	0.3446	0.3409	0.3372	0.3336	0.3300	0.3264	0.3228	0.3192	0.3156	0.3121
0.5	0.3085	0.3050	0.3015	0.2981	0.2946	0.2912	0.2877	0.2843	0.2810	0.2776
0.6	0.2743	0.2709	0.2676	0.2643	0.2611	0.2578	0.2546	0.2514	0.2483	0.2451
0.7	0.2420	0.2389	0.2358	0.2327	0.2296	0.2266	0.2236	0.2206	0.2177	0.2148
0.8	0.2119	0.2090	0.2061	0.2033	0.2005	0.1977	0.1949	0.1922	0.1894	0.1867
0.9	0.1841	0.1814	0.1788	0.1762	0.1736	0.1711	0.1685	0.1660	0.1635	0.1611
1.0	0.1587	0.1562	0.1539	0.1515	0.1492	0.1469	0.1446	0.1423	0.1401	0.1379
1.1	0.1357	0.1335	0.1314	0.1292	0.1271	0.1251	0.1230	0.1210	0.1190	0.1170
1.2	0.1151	0.1131	0.1112	0.1093	0.1075	0.1056	0.1038	0.1020	0.1003	0.0985
1.3	0.0968	0.0951	0.0934	0.0918	0.0901	0.0885	0.0869	0.0853	0.0838	0.0823
1.4	0.0808	0.0793	0.0778	0.0764	0.0749	0.0735	0.0721	0.0708	0.0694	0.0681
1.5	0.0668	0.0655	0.0643	0.0630	0.0618	0.0606	0.0594	0.0582	0.0571	0.0559
1.6	0.0548	0.0537	0.0526	0.0516	0.0505	0.0495	0.0485	0.0475	0.0465	0.0455
1.7	0.0446	0.0436	0.0427	0.0418	0.0409	0.0401	0.0392	0.0384	0.0375	0.0367
1.8	0.0359	0.0351	0.0344	0.0336	0.0329	0.0322	0.0314	0.0307	0.0301	0.0294
1.9	0.0287	0.0281	0.0274	0.0268	0.0262	0.0256	0.0250	0.0244	0.0239	0.0233
2.0	0.0228	0.0222	0.0217	0.0212	0.0207	0.0202	0.0197	0.0192	0.0188	0.0183
2.1	0.0179	0.0174	0.0170	0.0166	0.0162	0.0158	0.0154	0.0150	0.0146	0.0143
2.2	0.0139	0.0136	0.0132	0.0129	0.0125	0.0122	0.0119	0.0116	0.0113	0.0110
2.3	0.0107	0.0104	0.0102	0.0099	0.0096	0.0094	0.0091	0.0089	0.0087	0.0084
2.4	0.0082	0.0080	0.0078	0.0075	0.0073	0.0071	0.0069	0.0068	0.0066	0.0064
2.5	0.0062	0.0060	0.0059	0.0057	0.0055	0.0054	0.0052	0.0051	0.0049	0.0048
2.6	0.0047	0.0045	0.0044	0.0043	0.0041	0.0040	0.0039	0.0038	0.0037	0.0036
2.7	0.0035	0.0034	0.0033	0.0032	0.0031	0.0030	0.0029	0.0028	0.0027	0.0026
2.8	0.0026	0.0025	0.0024	0.0023	0.0023	0.0022	0.0021	0.0021	0.0020	0.0019
2.9	0.0019	0.0018	0.0018	0.0017	0.0016	0.0016	0.0015	0.0015	0.0014	0.0014
3.0	0.0013	0.0013	0.0013	0.0012	0.0012	0.0011	0.0011	0.0011	0.0010	0.0010
3.1	0.0010	0.0009	0.0009	0.0009	0.0008	0.0008	0.0008	0.0008	0.0007	0.0007
3.2	0.0007	0.0007	0.0006	0.0006	0.0006	0.0006	0.0006	0.0005	0.0005	0.0005
3.3	0.0005	0.0005	0.0005	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0003
3.4	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0002

FINAL EXAMINATION

SEMESTER/SESSION	: SEM I / 2019/2020	PROGRAMME CODE	: BFF
COURSE NAME	: CIVIL ENGINEERING STATISTICS	COURSE CODE	: BFC 34303

II. Standard Normal Distribution showing P (0 < Z < z)

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

FINAL EXAMINATION

SEMESTER/SESSION : SEM I / 2019/2020
COURSE NAME : CIVIL ENGINEERING STATISTICS
PROGRAMME CODE : BFF
COURSE CODE : BFC 34303

III. Critical Values of the Student's *t* distribution

df	**Level of significance for One-Tailed Test, α/2**						
	0.1	**0.05**	**0.025**	**0.01**	**0.005**	**0.001**	**0.0005**
	Level of significance for Two-Tailed Test, α						
	0.2	**0.1**	**0.05**	**0.02**	**0.01**	**0.002**	**0.001**
1	3.078	6.314	12.076	31.821	63.657	318.31	636.62
2	1.886	2.920	4.303	6.965	9.925	22.326	31.598
3	1.638	2.353	3.182	4.541	5.841	10.213	12.924
4	1.533	2.132	2.776	3.747	4.604	7.173	8.610
5	1.476	2.015	2.571	3.365	4.032	5.893	6.869
6	1.440	1.943	2.447	3.143	3.707	5.208	5.959
7	1.415	1.895	2.365	2.998	3.499	4.785	5.408
8	1.397	1.860	2.306	2.896	3.355	4.501	5.041
9	1.383	1.833	2.262	2.821	3.250	4.297	4.781
10	1.372	1.812	2.228	2.764	3.169	4.144	4.587
11	1.363	1.796	2.201	2.718	3.106	4.025	4.437
12	1.356	1.782	2.179	2.681	3.055	3.930	4.318
13	1.350	1.771	2.160	2.650	3.012	3.852	4.221
14	1.345	1.761	2.145	2.624	2.977	3.787	4.140
15	1.341	1.753	2.131	2.602	2.947	3.733	4.073
16	1.337	1.746	2.120	2.583	2.921	3.686	4.015
17	1.333	1.740	2.110	2.567	2.898	3.646	3.965
18	1.330	1.734	2.101	2.552	2.878	3.610	3.922
19	1.328	1.729	2.093	2.539	2.861	3.579	3.883
20	1.325	1.725	2.086	2.528	2.845	3.552	3.850
21	1.323	1.721	2.080	2.518	2.831	3.527	3.819
22	1.321	1.717	2.074	2.508	2.819	3.505	3.792
23	1.319	1.714	2.069	2.500	2.807	3.485	3.767
24	1.318	1.711	2.064	2.492	2.797	3.467	3.745
25	1.316	1.708	2.060	2.485	2.787	3.450	3.725
26	1.315	1.706	2.056	2.479	2.779	3.435	3.707
27	1.314	1.703	2.052	2.473	2.771	3.421	3.690
28	1.313	1.701	2.048	2.467	2.763	3.408	3.674
29	1.311	1.699	2.045	2.462	2.756	3.396	3.659
30	1.310	1.697	2.042	2.457	2.750	3.385	3.646

FINAL EXAMINATION

SEMESTER/SESSION : SEM I / 2019/2020
COURSE NAME : CIVIL ENGINEERING STATISTICS
PROGRAMME CODE : BFF
COURSE CODE : BFC 34303

IV. Critical Values of the *F* distribution

v₂	$\alpha = 0.05$									
	v₁									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	161.45	199.50	215.71	224.58	230.16	233.99	236.77	238.88	240.54	241.88
2	18.51	19.00	19.16	19.25	19.30	19.33	19.35	19.37	19.38	19.40
3	10.13	9.55	9.28	9.12	9.01	8.94	8.89	8.85	8.81	8.79
4	7.71	6.94	6.59	6.39	6.26	6.16	6.09	6.04	6.00	5.96
5	6.61	5.79	5.41	5.19	5.05	4.95	4.88	4.82	4.77	4.74
6	5.99	5.14	4.76	4.53	4.39	4.28	4.21	4.15	4.10	4.06
7	5.59	4.74	4.35	4.12	3.97	3.87	3.79	3.73	3.68	3.64
8	5.32	4.46	4.07	3.84	3.69	3.58	3.50	3.44	3.39	3.35
9	5.12	4.26	3.86	3.63	3.48	3.37	3.29	3.23	3.18	3.14
10	4.96	4.10	3.71	3.48	3.33	3.22	3.14	3.07	3.02	2.98

v₂	$\alpha = 0.10$									
	v₁									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	39.86	49.50	53.59	55.83	57.24	58.20	58.91	59.44	59.86	60.19
2	8.53	9.00	9.16	9.24	9.29	9.33	9.35	9.37	9.38	9.39
3	5.54	5.46	5.39	5.34	5.31	5.28	5.27	5.25	5.24	5.23
4	4.54	4.32	4.19	4.11	4.05	4.01	3.98	3.95	3.94	3.92
5	4.06	3.78	3.62	3.52	3.45	3.40	3.37	3.34	3.32	3.30
6	3.78	3.46	3.29	3.18	3.11	3.05	3.01	2.98	2.96	2.94
7	3.59	3.26	3.07	2.96	2.88	2.83	2.78	2.75	2.72	2.70
8	3.46	3.11	2.92	2.81	2.73	2.67	2.62	2.59	2.56	2.54
9	3.36	3.01	2.81	2.69	2.61	2.55	2.51	2.47	2.44	2.42
10	3.29	2.92	2.73	2.61	2.52	2.46	2.41	2.38	2.35	2.32

FINAL EXAMINATION

SEMESTER/SESSION : SEM I / 2019/2020
COURSE NAME : CIVIL ENGINEERING STATISTICS
PROGRAMME CODE : BFF
COURSE CODE : BFC 34303

V. Critical Values of the Chi-square, x^2 distribution

df	α					
	0.1	**0.05**	**0.025**	**0.01**	**0.005**	**0.001**
1	2.706	3.841	5.024	6.635	7.879	10.828
2	4.605	5.991	7.378	9.210	10.597	13.816
3	6.251	7.815	9.348	11.345	12.838	16.266
4	7.779	9.488	11.143	13.277	14.860	18.467
5	9.236	11.070	12.833	15.086	16.750	20.515
6	10.645	12.592	14.449	16.812	18.548	22.458
7	12.017	14.067	16.013	18.475	20.278	24.322
8	13.362	15.507	17.535	20.090	21.955	26.124
9	14.684	16.919	19.023	21.666	23.589	27.877
10	15.987	18.307	20.483	23.209	25.188	29.588
11	17.275	19.675	21.920	24.725	26.757	31.264
12	18.549	21.026	23.337	26.217	28.300	32.909
13	19.812	22.362	24.736	27.688	29.819	34.528
14	21.064	23.685	26.119	29.141	31.319	36.123
15	22.307	24.996	27.488	30.578	32.801	37.697
16	23.542	26.296	28.845	32.000	34.267	39.252
17	24.769	27.587	30.191	33.409	35.718	40.790
18	25.989	28.869	31.526	34.805	37.156	42.312
19	27.204	30.144	32.852	36.191	38.582	43.820
20	28.412	31.410	34.170	37.566	39.997	45.315
21	29.615	32.671	35.479	38.932	41.401	46.797
22	30.813	33.924	36.781	40.289	42.796	48.268
23	32.007	35.172	38.076	41.638	44.181	49.728
24	33.196	36.415	39.364	42.980	45.559	51.179
25	34.382	37.652	40.646	44.314	46.928	52.620
26	35.563	38.885	41.923	45.642	48.290	54.052
27	36.741	40.113	43.195	46.963	49.645	55.476
28	37.916	41.337	44.461	48.278	50.993	56.892
29	39.087	42.557	45.722	49.588	52.336	58.301
30	40.256	43.773	46.979	50.892	53.672	59.703

FINAL EXAMINATION

SEMESTER/SESSION : SEM I / 2019/2020
COURSE NAME : CIVIL ENGINEERING STATISTICS
PROGRAMME CODE : BFF
COURSE CODE : BFC 34303

VI. Critical Values of the Mann-Whitney U (Two-tailed)

		n_1												
n_2	**α**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
3	**0.05**	0	0	0	1	1	2	2	3	3	4	4	5	5
	0.01	0	0	0	0	0	0	0	0	0	1	1	1	2
4	**0.05**	0	0	1	2	3	4	4	5	6	7	8	9	10
	0.01	0	0	0	0	0	1	1	2	2	3	3	4	5
5	**0.05**	0	1	2	3	5	6	7	8	9	11	12	13	14
	0.01	0	0	0	1	1	2	3	4	5	6	7	7	8
6	**0.05**	1	2	3	5	6	8	10	11	13	14	16	17	19
	0.01	0	0	1	2	3	4	5	6	7	9	10	11	12
7	**0.05**	1	3	5	6	8	10	12	14	16	18	20	22	24
	0.01	0	0	1	3	4	6	7	9	10	12	13	15	16
8	**0.05**	2	4	6	8	10	13	15	17	19	22	24	26	29
	0.01	0	1	2	4	6	7	9	11	13	15	17	18	20
9	**0.05**	2	4	7	10	12	15	17	20	23	26	28	31	34
	0.01	0	1	3	5	7	9	11	13	16	18	20	22	24
10	**0.05**	3	5	8	11	14	17	20	23	26	29	33	36	39
	0.01	0	2	4	6	9	11	13	16	18	21	24	26	29
11	**0.05**	3	6	9	13	16	19	23	26	30	33	37	40	44
	0.01	0	2	5	7	10	13	16	18	21	24	27	30	33
12	**0.05**	4	7	11	14	18	22	26	29	33	37	41	45	49
	0.01	1	3	6	9	12	15	18	21	24	27	31	24	37
13	**0.05**	4	8	12	16	20	24	28	33	37	41	45	50	54
	0.01	1	3	7	10	13	17	20	24	27	31	34	38	42
14	**0.05**	5	9	13	17	22	26	31	36	40	45	50	55	59
	0.01	1	4	7	11	15	18	22	26	30	34	38	42	46
15	**0.05**	5	10	14	19	24	29	34	39	44	49	54	59	64
	0.01	2	5	8	12	16	20	24	29	33	37	42	46	51

FINAL EXAMINATION

SEMESTER/SESSION : SEM I / 2019/2020
COURSE NAME : CIVIL ENGINEERING STATISTICS
PROGRAMME CODE : BFF
COURSE CODE : BFC 34303

VII. Critical Values of the Mann-Whitney U (One-tailed)

		n_1												
n_2	**α**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
3	**0.05**	0	0	1	2	2	3	4	4	5	5	6	7	7
	0.01	0	0	0	0	0	0	1	1	1	2	2	2	3
4	**0.05**	0	1	2	3	4	5	6	7	8	9	10	11	12
	0.01	0	0	0	1	1	2	3	3	4	5	5	6	7
5	**0.05**	1	2	4	5	6	8	9	11	12	13	15	16	18
	0.01	0	0	1	2	3	4	5	6	7	8	9	10	11
6	**0.05**	2	3	5	7	8	10	12	14	16	17	18	21	23
	0.01	0	1	2	3	4	6	7	8	9	11	12	13	15
7	**0.05**	2	4	6	8	11	13	15	17	19	21	24	26	28
	0.01	0	1	3	4	6	7	9	11	12	14	16	17	19
8	**0.05**	3	5	8	10	13	15	18	20	23	26	28	31	33
	0.01	0	2	4	6	7	9	11	13	15	17	20	22	24
9	**0.05**	4	6	9	12	15	18	21	24	27	30	33	36	39
	0.01	1	3	5	7	9	11	14	16	18	21	23	26	28
10	**0.05**	4	7	11	14	17	20	24	27	31	34	37	41	44
	0.01	1	3	6	8	11	13	16	19	22	24	27	30	33
11	**0.05**	5	8	12	16	19	23	27	31	34	38	42	46	50
	0.01	1	4	7	9	12	15	18	22	25	28	31	34	37
12	**0.05**	5	9	13	17	21	26	30	34	38	42	47	51	55
	0.01	2	5	8	11	14	17	21	24	28	31	35	38	42
13	**0.05**	6	10	15	19	24	28	33	37	42	47	51	56	61
	0.01	2	5	9	12	16	20	23	27	31	35	39	43	47
14	**0.05**	7	11	16	21	26	31	36	41	46	51	56	61	66
	0.01	2	6	10	13	17	22	26	30	34	38	43	47	51
15	**0.05**	7	12	18	23	28	33	39	44	50	55	61	66	72
	0.01	3	7	11	15	19	24	28	33	37	42	47	51	56