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OFFICE OF THE DEPUTY PRINCIPAL
ACADEMICS, STUDENT AFFAIRS AND RESEARCH

UNIVERSITY EXAMINATIONS

2020 /2021 ACADEMIC YEAR

FOURTH YEAR SECOND SEMESTER REGULAR EXAMINATION

FOR THE DEGREE OF BACHELOR OF SCIENCE (APPLIED STATISTICS WITH COMPUTING)

COURSE CODE: **STA 430**

COURSE TITLE: **NON PARAMETRICS AND ROBUST METHODS**

DATE: 16/7/2021 **TIME: 0800-1100HRS**

INSTRUCTION TO CANDIDATES

- **SEE INSIDE**

THIS PAPER CONSISTS OF 5 PRINTED PAGES **PLEASE TURN OVER**

REGULAR – MAIN EXAM

STA 430: NON PARAMETRICS AND ROBUST METHODS

STREAM: ASC **DURATION: 3 Hours**

INSTRUCTION TO CANDIDATES

Answer **ALL** questions from section A and any **THREE** from section B.

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SECTION A [31 Marks]. Answer ALL questions.

QUESTION ONE [15 Marks]

a) Distinguish between a parametric an non parametric test [2 Marks]
b) State three advantages of non-parametric methods [3 Marks]
c) How does the Wilcoxon signed-rank test improve on the sign test? [2 Marks]
d) What is your understanding of contingency table? Draw an example [4 Marks]
e) What do robust methods refer to? Cite some examples [4 Marks]

QUESTION TWO [16 Marks]

a) Using an example for each case explain the concepts simple and composite hypothesis. [4 Marks]
b) Consider the following times of anagrams data under conditions P and Q

Condition P	3	5	97	12	
Condition Q	23	37	64	24	14

Compute Mann-Whitney U Statistic [4 Marks]
c) For every non-parametric test there is an equivalent for each parametric general type of test. State three broad categories that these tests fall into. [3 Marks]
d) Give R codes you would use perform to χ^2 test of independence. [3 Marks]
e) What is an equivalent non-parametric test to the following
   i) One sample t-test [1 Mark]
   ii) Two sample t-test [1 Mark]

SECTION B [39 Marks] Answer any THREE questions]

QUESTION THREE [13 Marks]

a) Discuss the advantages and disadvantages of sign test. [3 Marks]
b) Consider the data on the heights of twelve infants given below:

18.2, 21.4, 22.6, 17.4, 17.6, 16.7, 17.1, 21.4, 20.1, 17.9, 16.8, 23.1

Perform Kolmogorov Smirnov test to test the hypothesis that data came from normal population at $\alpha = 0.01$ significance level [10 Marks]

QUESTION FOUR [13 Marks]

a) Give any three assumptions that apply when Mann Whitney test is conducted. [3 Marks]

b) What are rank tests? [2 Marks]

c) Conduct a test of outliers to detect any outliers in the data set and make necessary comment on your results. Make any necessary comments

8.9 6.2 7.2 5.4 3.7 2.8 22.2 12.7 6.9 3.1 29.8

[8 Marks]

QUESTION FIVE [13 Marks]

a) Give test statistic for Wilcoxon signed rank test and give its three assumptions. [4 Marks]

b) An automotive development engineer is investigating the properties of two fuel injection systems in order to determine whether they exhibit any significant difference in the level of fuel economy measured on different cars. The systems are fitted to 12 cars and a test is run ensuring that each injection system is used on each car under conditions which are as uniform as possible. The fuel consumption figures (in miles per gallon) obtained are given in the table below.

Car	1	2	3	4	5	6	7	8	9	10	11	12
System 1	27.6	29.4	29.5	27.2	25.8	26.9	26.7	28.9	27.3	29.2	27.8	29.2
System 2	26.3	31.0	28.2	26.1	27.6	25.8	28.2	27.6	26.9	30.3	26.9	28.3

Use the Wilcoxon signed-rank test to decide whether the median fuel consumption figures are significantly different at the 5% level of significance [5 Marks]

c) Outline the procedure that gives the output on the right given the data on the left on two methods of teaching, include R codes. [4 Marks]

Method 1	Method 2
48	14
40	18
39	20
50	10
41	12
38	102
53	17

```
        Wilcoxon rank sum test

data:  Method_1 and Method_2
W = 42, p-value = 0.02622
alternative hypothesis: true location shift is not equal to 0
```

QUESTION SIX [13 Marks]

a) When is a permutation test used? Give its assumptions. [5 Marks]

b) In an experiment the dopamine concentrations in the brains of six rats on toluene treatment and eight control rats were recorded as follows. The first six values are treatments while the last eight are controls.

3120, 2104, 1664, 2481, 2603, 2301, 1620, 1743, 1397, 1503, 2339, 2090, 2231, 1225

Perform a permutation test. [8 Marks]

QUESTION SEVEN [13 Marks]

a) Suppose thirteen participants were asked to rate their satisfaction for a new product introduced in the market. The results after analysis were as shown in the output below.

Satisfaction * Gender Crosstabulation

			Gender		Total
			male	female	
Satisfaction	positive	Count	4	1	5
		Expected Count	2.3	2.7	5.0
	negative	Count	2	6	8
		Expected Count	3.7	4.3	8.0
Total		Count	6	7	13
		Expected Count	6.0	7.0	13.0

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Phi	.537	.053
	Cramer's V	.537	.053
N of Valid Cases		13	

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	3.745[a]	1	.053		
Continuity Correction[b]	1.859	1	.173		
Likelihood Ratio	3.943	1	.047		
Fisher's Exact Test				.103	.068
Linear-by-Linear Association	3.457	1	.063		
N of Valid Cases	13				

a. 4 cells (100.0%) have expected count less than 5. The minimum expected count is 2.31.

b. Computed only for a 2x2 table

Why was fisher's exact test preferred? Give a brief report on the above findings. [5 Marks]

b) Suppose twenty observations were chosen randomly from a continuous uniform distribution over [0,1] and recorded as follows.

0.0123	0.1039	0.1954	0.2621	0.2802
0.3217	0.3645	0.3919	0.4240	0.4814
0.5139	0.5846	0.6275	0.6541	0.6889
0.7621	0.8320	0.8871	0.9249	0.9634

Determine the value of D_n and test the null hypothesis that the square roots of these values also have a continuous uniform distribution over [0,1] [$D_{20}^{+} = 0.232$]. [8 Marks]

TABLE A13 Quantiles of the Kolmogorov Test Statistic[a]

One-Sided Test p =	0.90	0.95	0.975	0.99	0.995		0.90	0.95	0.975	0.99	0.995
Two-Sided Test p =	0.80	0.90	0.95	0.98	0.99		0.80	0.90	0.95	0.98	0.99
n = 1	0.900	0.950	0.975	0.990	0.995	n = 21	0.226	0.259	0.287	0.321	0.344
2	0.684	0.776	0.842	0.900	0.929	22	0.221	0.253	0.281	0.314	0.337
3	0.565	0.636	0.708	0.785	0.829	23	0.216	0.247	0.275	0.307	0.330
4	0.493	0.565	0.624	0.689	0.734	24	0.212	0.242	0.269	0.301	0.323
5	0.447	0.509	0.563	0.627	0.669	25	0.208	0.238	0.264	0.295	0.317
6	0.410	0.468	0.519	0.577	0.617	26	0.204	0.233	0.259	0.290	0.311
7	0.381	0.436	0.483	0.538	0.576	27	0.200	0.229	0.254	0.284	0.305
8	0.358	0.410	0.454	0.507	0.542	28	0.197	0.225	0.250	0.279	0.300
9	0.339	0.387	0.430	0.480	0.513	29	0.193	0.221	0.246	0.275	0.295
10	0.323	0.369	0.409	0.457	0.489	30	0.190	0.218	0.242	0.270	0.290
11	0.308	0.352	0.391	0.437	0.468	31	0.187	0.214	0.238	0.266	0.285
12	0.296	0.338	0.375	0.419	0.449	32	0.184	0.211	0.234	0.262	0.281
13	0.285	0.325	0.361	0.404	0.432	33	0.182	0.208	0.231	0.258	0.277
14	0.275	0.314	0.349	0.390	0.418	34	0.179	0.205	0.227	0.254	0.273
15	0.266	0.304	0.338	0.377	0.404	35	0.177	0.202	0.224	0.251	0.269
16	0.258	0.295	0.327	0.366	0.392	36	0.174	0.199	0.221	0.247	0.265
17	0.250	0.286	0.318	0.355	0.381	37	0.172	0.196	0.218	0.244	0.262
18	0.244	0.279	0.309	0.346	0.371	38	0.170	0.194	0.215	0.241	0.258
19	0.237	0.271	0.301	0.337	0.361	39	0.168	0.191	0.213	0.238	0.255
20	0.232	0.265	0.294	0.329	0.352	40	0.165	0.189	0.210	0.235	0.252
				Approximation for $n > 40$			$\frac{1.07}{\sqrt{n}}$	$\frac{1.22}{\sqrt{n}}$	$\frac{1.36}{\sqrt{n}}$	$\frac{1.52}{\sqrt{n}}$	$\frac{1.63}{\sqrt{n}}$

TABLE A12 Quantiles of the Wilcoxon Signed Ranks Test Statistic

	$w_{0.005}$	$w_{0.01}$	$w_{0.025}$	$w_{0.05}$	$w_{0.10}$	$w_{0.20}$	$w_{0.30}$	$w_{0.40}$	$w_{0.50}$	$\frac{n(n+1)}{2}$
n = 4	0	0	0	0	1	3	3	4	5	10
5	0	0	0	1	3	4	5	6	7.5	15
6	0	0	1	3	4	6	8	9	10.5	21
7	0	1	3	4	6	9	11	12	14	28
8	1	2	4	6	9	12	14	16	18	36
9	2	4	6	9	11	15	18	20	22.5	45
10	4	6	9	11	15	19	22	25	27.5	55
11	6	8	11	14	18	23	27	30	33	66
12	8	10	14	18	22	28	32	36	39	78
13	10	13	18	22	27	33	38	42	45.5	91
14	13	16	22	26	32	39	44	48	52.5	105
15	16	20	26	31	37	45	51	55	60	120
16	20	24	30	36	43	51	58	63	68	136
17	24	28	35	42	49	58	65	71	76.5	153
18	28	33	41	48	56	66	73	80	85.5	171
19	33	38	47	54	63	74	82	89	95	190
20	38	44	53	61	70	83	91	98	105	210
21	44	50	59	68	78	91	100	108	115.5	231
22	49	56	67	76	87	100	110	119	126.5	253
23	55	63	74	84	95	110	120	130	138	276
24	62	70	82	92	105	120	131	141	150	300
25	69	77	90	101	114	131	143	153	162.5	325
26	76	85	99	111	125	142	155	165	175.5	351
27	84	94	108	120	135	154	167	178	189	378
28	92	102	117	131	146	166	180	192	203	406
29	101	111	127	141	158	178	193	206	217.5	435
30	110	121	138	152	170	191	207	220	232.5	465

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