National Exams May 2017

04-Env-B7, Environmental Sampling and Analysis

3 hours duration

NOTES:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.

2. This is a closed book exam. Use either an approved non-programmable Sharp or Casio calculator. Write the name and model designation of the calculator, on the first inside left hand sheet, of the exam workbook.

3. Answer all 4 questions in Part A and any 2 questions in Part B.

4. Part marks are as shown.

5. Use the statistical tables provided.

   Table Provided:

   t-distribution
   F-distribution

Marking Scheme

1.	20 marks total	(3 parts: 8 + 5 + 7 marks)
2.	20 marks total	(3 parts, 10, 5 and 5 marks each)
3.	10 marks total	13 blanks to fill in.
4.	10 marks total	(descriptive)
5.	20 marks total	(a) 10 marks (b) 10 marks
6.	20 marks total	8 items, (4 x 2 marks, 4 x 3 marks)
7.	20 marks total	(descriptive)

Part A: Answer all four questions

1. a) List the two properties which make Simple Random Sampling (SRS) the standard by which other sampling methods are judged. Explain why SRS is not always used in practice. List 4 other methods used in environmental sampling besides SRS. [8 marks]

b) List 5 typical characteristics of environmental data [5 marks].

c) Indicate whether each of the statements below is true or false: [1 mark each]

(i) For statistical significance, the α-value must be greater than the p-value.

(ii) An ANOVA is for testing differences among variances.

(iii) We can increase the power of a statistical test by decreasing α.

(iv) As the sample size of a set of data increases, the data tend to be normally distributed.

(v) Pearson's correlation coefficient r can be used as a measure of nonlinear association.

(vi) The attained significance of a sample statistic is independent on sample size.

(vii) Nonparametric statistical tests are usually preferred over parametric tests for environmental data analysis.

2. Pollution concentrations were measured before and after treatment at a certain location.

Pre-treatment:	68.3	66.5	62.9	64.8	66.6	69.4	65.2	62.5	70.4	62.2
Post treatment:	61.8	60.1	60.2	63.5	68.5	61.8	62.1	61.2	65.1	68.9

It is desired to show that the pollution values obtained after treatment are significantly lower than before treatment at the 5% significance level.

a) Carry out the correct t-test and justify your choice of the test. What is the conclusion from the test? [10 marks]

b) What is the main assumption of the test used? Use a graphical method to verify the assumption of the test used. [5 marks]

c) What alternative statistical tests can also be used? [5 marks]

3. Fill in the blanks in the following output for data from a completely randomized, two factor field study. Factor A has 3 levels (Locations) and Factor B has 4 levels (Seasons). Two replications were available for each treatment combination. Test for statistical significance at the 5% level. State clearly the conclusions from the study. [10 marks]

2-Way ANOVA

Source	SS	DF	MS	F
Location (A)	______	____	80.17	______
Season (B)	12.46	____	_____	______
Interaction (AB)	______	____	_____	______
Error	______	____	3.79	
Total	262.96	____		

4. Samples of soil, water, or air collected in the field are often sent to a certified laboratory for analysis. Discuss the protocol that should be followed so that the field data collected would be an accurate representation of the actual contaminants found in the samples. Points you should address include: types of sample collection methods, sample preparation and preservation techniques, quality assurance and control, data management, and sources of errors. [10 marks]

Part B: Answer any 2 questions

5. 13 samples of nitrate concentrations were taken from a well site. The data are as follows:

13 5 8 120 9 2 45 24 57 16 48 89 8

Partial summary statistics obtained from a computer package are given below.

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 N        Mean      Median     StDev    Minimum    Maximum
13        34.3        16.0      36.4        2.0      120.0
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a) Draw accurately a dotplot and a standard boxplot for the data. Indicate clearly where the fences are for the boxplot. Estimate also the first and third quartiles. Indicate whether any outliers exist. [10 marks]

b) From the numerical summary and the boxplot, what can you conclude about the characteristics of the data? Compute also the quartile skew and coefficient of skewness. [10 marks]

6. Provide a brief explanation/definition of the following terms commonly used in environmental sampling and analysis:

a) Background or baseline concentration	[2 marks]
b) Censored data	[2 marks]
c) Composite sample	[3 marks]
d) Colorimetric analysis versus instrumental analysis	[3 marks]
e) Hotspots	[2 marks]
f) Maximum Contaminant Level (MCL)	[3 marks]
g) Assessment monitoring versus compliance monitoring	[3 marks]
h) Data QA/QC	[2 marks]

7. Consider an environmental monitoring program that you have been involved with. What were the short and long term objectives of the monitoring program? What were sampled? How were the samples collected? What sampling design(s) were used? How often was sampling done? How many samples were collected and over what period? What statistical hypotheses were being tested? What statistical analyses were carried out? What kinds of laboratory analyses were done? What relevant standards were used and compared to? Discuss any other relevant issues related to this monitoring program. Marks will be awarded based on the thoroughness of your answer. [20 marks]

t-distribution table

Critical Values of the t-Distribution

v	α						
	0.40	**0.30**	**0.20**	**0.15**	**0.10**	**0.05**	**0.025**
1	0.325	0.727	1.376	1.963	3.078	6.314	12.706
2	0.289	0.617	1.061	1.386	1.886	2.920	4.303
3	0.277	0.584	0.978	1.250	1.638	2.353	3.182
4	0.271	0.569	0.941	1.190	1.533	2.132	2.776
5	0.267	0.559	0.920	1.156	1.476	2.015	2.571
6	0.265	0.553	0.906	1.134	1.440	1.943	2.447
7	0.263	0.549	0.896	1.119	1.415	1.895	2.365
8	0.262	0.546	0.889	1.108	1.397	1.860	2.306
9	0.261	0.543	0.883	1.100	1.383	1.833	2.262
10	0.260	0.542	0.879	1.093	1.372	1.812	2.228
11	0.260	0.540	0.876	1.088	1.363	1.796	2.201
12	0.259	0.539	0.873	1.083	1.356	1.782	2.179
13	0.259	0.537	0.870	1.079	1.350	1.771	2.160
14	0.258	0.537	0.868	1.076	1.345	1.761	2.145
15	0.258	0.536	0.866	1.074	1.341	1.753	2.131
16	0.258	0.535	0.865	1.071	1.337	1.746	2.120
17	0.257	0.534	0.863	1.069	1.333	1.740	2.110
18	0.257	0.534	0.862	1.067	1.330	1.734	2.101
19	0.257	0.533	0.861	1.066	1.328	1.729	2.093
20	0.257	0.533	0.860	1.064	1.325	1.725	2.086
21	0.257	0.532	0.859	1.063	1.323	1.721	2.080
22	0.256	0.532	0.858	1.061	1.321	1.717	2.074
23	0.256	0.532	0.858	1.060	1.319	1.714	2.069
24	0.256	0.531	0.857	1.059	1.318	1.711	2.064
25	0.256	0.531	0.856	1.058	1.316	1.708	2.060
26	0.256	0.531	0.856	1.058	1.315	1.706	2.056
27	0.256	0.531	0.855	1.057	1.314	1.703	2.052
28	0.256	0.530	0.855	1.056	1.313	1.701	2.048
29	0.256	0.530	0.854	1.055	1.311	1.699	2.045
30	0.256	0.530	0.854	1.055	1.310	1.697	2.042
40	0.255	0.529	0.851	1.050	1.303	1.684	2.021
60	0.254	0.527	0.848	1.045	1.296	1.671	2.000
120	0.254	0.526	0.845	1.041	1.289	1.658	1.980
∞	0.253	0.524	0.842	1.036	1.282	1.645	1.960

F - Distribution ($\alpha = 0.05$ in the Right Tail)

	df_2 \ df_1	Numerator Degrees of Freedom								
		1	2	3	4	5	6	7	8	9
Denominator Degrees of Freedom	1	161.45	199.50	215.71	224.58	230.16	233.99	236.77	238.88	240.54
	2	18.513	19.000	19.164	19.247	19.296	19.330	19.353	19.371	19.385
	3	10.128	9.5521	9.2766	9.1172	9.0135	8.9406	8.8867	8.8452	8.8123
	4	7.7086	9.9443	6.5914	6.3882	6.2561	6.1631	6.0942	6.0410	6.9988
	5	6.6079	5.7861	5.4095	5.1922	5.0503	4.9503	4.8759	4.8183	4.7725
	6	5.9874	5.1433	4.7571	4.5337	4.3874	4.2839	4.2067	4.1468	4.0990
	7	5.5914	4.7374	4.3468	4.1203	3.9715	3.8660	3.7870	3.7257	3.6767
	8	5.3177	4.4590	4.0662	3.8379	3.6875	3.5806	3.5005	3.4381	3.3881
	9	5.1174	4.2565	3.8625	3.6331	3.4817	3.3738	3.2927	3.2296	3.1789
	10	4.9646	4.1028	3.7083	3.4780	3.3258	3.2172	3.1355	3.0717	3.0204
	11	4.8443	3.9823	3.5874	3.3567	3.2039	3.0946	3.0123	2.9480	2.8962
	12	4.7472	3.8853	3.4903	3.2592	3.1059	2.9961	2.9134	2.8486	2.7964
	13	4.6672	3.8056	3.4105	3.1791	3.0254	2.9153	2.8321	2.7669	2.7144
	14	4.6001	3.7389	3.3439	3.1122	2.9582	2.8477	2.7642	2.6987	2.6458
	15	4.5431	3.6823	3.2874	3.0556	2.9013	2.7905	2.7066	2.6408	2.5876
	16	4.4940	3.6337	3.2389	3.0069	2.8524	2.7413	2.6572	2.5911	2.5377
	17	4.4513	3.5915	3.1968	2.9647	2.8100	2.6987	2.6143	2.5480	2.4943
	18	4.4139	3.5546	3.1599	2.9277	2.7729	2.6613	2.5767	2.5102	2.4563
	19	4.3807	3.5219	3.1274	2.8951	2.7401	2.6283	2.5435	2.4768	2.4227
	20	4.3512	3.4928	3.0984	2.8661	2.7109	2.5990	2.5140	2.4471	2.3928
	21	4.3248	3.4668	3.0725	2.8401	2.6848	2.5727	2.4876	2.4205	2.3660
	22	4.3009	3.4434	3.0491	2.8167	2.6613	2.5491	2.4638	2.3965	2.3419
	23	4.2793	3.4221	3.0280	2.7955	2.6400	2.5277	2.4422	2.3748	2.3201
	24	4.2597	3.4028	3.0088	2.7763	2.6207	2.5082	2.4226	2.3551	2.3002
	25	4.2417	3.3852	2.9912	2.7587	2.6030	2.4904	2.4047	2.3371	2.2821
	26	4.2252	3.3690	2.9752	2.7426	2.5868	2.4741	2.3883	2.3205	2.2655
	27	4.2100	3.3541	2.9604	2.7278	2.5719	2.4591	2.3732	2.3053	2.2501
	28	4.1960	3.3404	2.9467	2.7141	2.5581	2.4453	2.3593	2.2913	2.2360
	29	4.1830	3.3277	2.9340	2.7014	2.5454	2.4324	2.3463	2.2783	2.2229
	30	4.1709	3.3158	2.9223	2.6896	2.5336	2.4205	2.3343	2.2662	2.2107
	40	4.0847	3.2317	2.8387	2.6060	2.4495	2.3359	2.2490	2.1802	2.1240
	60	4.0012	3.1504	2.7581	2.5252	2.3683	2.2541	2.1665	2.0970	2.0401
	120	3.9201	3.0718	2.6802	2.4472	2.2899	2.1750	2.0868	2.0164	1.9588
	∞	3.8415	2.9957	2.6049	2.3719	2.2141	2.0986	2.0096	1.9384	1.8799