

SMA2204

**NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY**  
**DEPARTMENT OF APPLIED MATHEMATICS**  
**B.Sc. PART II HONOURS SUPPLEMENTARY EXAMINATIONS 2004**

**SMA 2204 – APPLIED STATISTICS**

**AUGUST 2004**

**3 HOURS (100 Marks)**

**This paper has 4 pages**

Answer **FOUR** questions: Question 1 in **SECTION A** (28 Marks) and **THREE** from **SECTION B** (24 Marks each). Where a question contains subdivisions, the mark value of each subdivision is indicated in brackets.

Candidates are expected to spend not more than one hour on Question 1. Calculators may be used. Statistical Tables and graph paper are provided, however, Statistical Tables should not be marked or taken out of the examination room. **GOOD LUCK!**

**SECTION A (COMPULSORY)**

1. (a) Suppose that during periods of transcendental meditation the reduction of a person's oxygen consumption is a random variable having a normal distribution with mean  $\mu = 37.6$  cc per minute and standard deviation  $\sigma = 4.6$  cc per minute. Find the probabilities that during a period of transcendental meditation a person's oxygen consumption will be reduced by
- (i) at least 44.5 cc per minute **(2 marks)**
- (ii) at most 35.0 cc per minute **(2 marks)**
- (iii) from 30.0 to 40.0 cc per minute **(2 marks)**
- (b) A food inspector, examining 12 bottles of a certain brand of peanut butter, obtained the following percentages of impurities: 2.3, 1.9, 2.1, 2.8, 2.3, 3.6, 1.4, 1.8, 2.1, 3.2, 2.0, and 1.9. Assuming that such determinations are normally distributed, find a 99% confidence interval for the average percentage of impurities in this brand of peanut butter. **(4 marks)**
- (c) In the comparison of two kinds of paint, a consumer testing service finds that four five-litre containers of one brand cover an average of 51.2 square metres with a standard deviation of 3.1 square metres, while four five-litre containers of another brand cover an average of 49.2 square metres with a standard deviation of 2.6 square metres. Assuming that the two populations are normal and have equal variances, test at the 5% level of significance whether the two brands of paint are significantly different with respect to area covered. **(4 marks)**

- (d) The following sample data pertain to the shipments received by a large firm from three different vendors:

	Number Rejected	Number Imperfect but Acceptable	Number Perfect
Vendor A	12	23	89
Vendor B	8	12	62
Vendor C	21	30	119

Test at the 0.01 level of significance whether the three vendors supply products of equal quality. **(6 marks)**

- (e) Four catalysts that may affect the concentration of one component in a three-component liquid mixture are being investigated. The following concentrations are obtained:

Catalyst 1:	58.2	57.2	58.4	55.8	54.9
Catalyst 2:	56.3	54.5	57.0	55.3	
Catalyst 3:	50.1	54.2	55.4		
Catalyst 4:	52.9	49.9	50.0	51.7	

Perform an appropriate analysis to test whether the four catalysts have the same effect on the concentration. Use the 5% level of significance. **(8 marks)**

### SECTION B (ANSWER ANY THREE QUESTIONS)

2. (a) To determine the effectiveness of an industrial safety programme, the following data were collected over a period of a year on the average weekly loss of man-hours due to accidents in 12 plants "before and after" the programme was put into operation:

Plant	1	2	3	4	5	6	7	8	9	10	11	12
Before	50	87	37	141	59	65	24	88	25	36	50	35
After	41	75	35	129	60	53	26	85	29	31	48	37

Use 0.01 level of significance to test the null hypothesis that the safety programme is not effective against a suitable one-sided alternative hypothesis. What assumption have you made? **(10 marks)**

- (b) The mean reaction times, in hundredths of a second, of two groups of subjects to a flashing-light stimulus were recorded. The first group consisted of subjects who were new to the experimental investigations while the subjects in the second group had taken part in previous experiments.

New Subjects	2.7	3.0	3.3	2.9	3.5	2.7	3.0	3.1	2.8	3.0
Experienced Subjects	2.7	2.5	3.0	2.7	2.6	2.5	2.9	2.7		

Test at the 5% level of significance if experience has had an effect on the mean response time. What assumptions have you made? (10 marks)

- (c) What are the advantages and disadvantages of a Paired Comparison Design over a Two-Sample t-test? (4 marks)

3. An experiment was performed in order to investigate the effect of four different fuels and three different types of launchers on the range of a certain rocket and the following data were obtained: (ranges are in km)

	Fuel 1	Fuel 2	Fuel 3	Fuel 4
Launcher X	45.9	57.6	52.2	41.7
Launcher Y	46.0	51.0	50.1	38.8
Launcher Z	45.7	56.9	55.3	48.1

Test at the 5% level of significance whether there are significant differences among the four fuels and among the three launchers. (24 marks)

4. A bacteriologist is interested in the effect of two different culture mediums and two different times on the growth of a particular virus. She performs six replicates of a  $2^2$  factorial experiment, making the runs in random order and obtains the following data:

Time	Culture Medium			
	1		2	
12 hr	21	22	25	26
	23	28	24	25
	20	26	29	27
18 hr	37	39	31	34
	38	38	29	33
	35	36	30	35

- (a) Construct a two-way table of totals and then carry out a preliminary analysis of variance to test whether there are any significant differences among the four treatment combinations at the 5% level of significance. (10 marks)
- (b) Carry out the final (complete) analysis of variance to test for the significance of main effects and interaction at the 5% level of significance. (10 marks)
- (c) Give an appropriate table of means and relevant standard errors for comparisons. (4 marks)

5. A test was performed in order to determine the relationship between the chemical content of a particular constituent ( $y$ ) (in grams per litre) in solution and the crystallization temperature ( $x$ ) (in degrees Kelvin). The results were as follows:

$x$	0.3	0.4	1.2	2.3	3.1	4.2	5.3
$y$	3.2	2.4	4.3	5.4	6.6	7.8	8.8

- (a) Draw a scatter diagram of ( $y$ ) against ( $x$ ) on graph paper. Fit the least squares regression line  $y = \beta_0 + \beta_1x + \varepsilon$  and draw your fitted line on your scatter diagram. (10 marks)
- (b) Carry out an analysis of variance to test at the 0.05 level of significance whether the slope is significantly different from zero. Compute the coefficient of determination,  $r^2$ , and interpret it. (8 marks)
- (c) Predict the chemical content  $y$  at the crystallization temperature of 3.6 degrees Kelvin. Compute the standard error of the predicted value and hence find the 95% confidence interval of this prediction. (6 marks)
6. Explain clearly, using the following data, how the following are constructed:

23	29	40	28	15
22	46	39	22	17
26	33	35	49	20
36	25	15	31	17
43	54	36	30	30
40	27	24	20	28
22	37	17	39	42
17	22	9	26	29

- (a) Stem and leaf plot, (8 marks)
- (b) Histogram, (8 marks)
- (c) Box plot. (8 marks)

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