EXAMINATIONS OF THE ROYAL STATISTICAL SOCIETY
(formerly the Examinations of the Institute of Statisticians)

HIGHER CERTIFICATE IN STATISTICS, 2000

CERTIFICATE IN OFFICIAL STATISTICS, 2000

Paper II : Statistical Methods

Time Allowed: Three Hours

Candidates should answer **FIVE** *questions.*

All questions carry equal marks.
The number of marks allotted for each part-question is shown in brackets.

Graph paper and Official tables are provided.

Candidates may use silent, cordless, non-programmable electronic calculators.

Where a calculator is used the ***method*** *of calculation should be stated in full.*

Note that $\binom{n}{r}$ *is the same as* ${}^{n}C_{r}$ *and that* ln *stands for* $\log_e$.

This examination paper consists of 8 printed pages. This front cover is page 1. The reverse of the front cover, which is intentionally left blank, is page 2. Question 1 starts on page 3.

There are 8 questions altogether in the paper.

1. The numbers of goals scored in league matches by the highest scoring player from each of the 44 teams making up the two divisions of a local football league were as follows:

Division 1 34 29 28 27 27 26 25 24 24 23 22 21 20 20 20 19 19 18 17 16 16 14

Division 2 39 38 37 34 34 33 32 31 29 29 29 28 28 26 25 24 24 23 21 18 15 15

(i) Draw a stem and leaf diagram and obtain appropriate measures of location and dispersion for the data from each division.

(8)

(ii) What do the data, diagrams and your measures of location and dispersion show?

(4)

(iii) Obtain a 95% confidence interval for the difference in the mean number of goals scored by the highest scoring player in each team between the two divisions. On what assumptions is your confidence interval based?

(8)

2. An experiment was conducted to test the effect of a new drug on viral infection. The infection was induced in 48 mice and the mice were randomly spilt into two groups of 24. The first group, the control group, received no treatment for the infection. The second group received the drug. After a 30-day period, the numbers of survivors in the two groups were noted. In the control group, 10 mice survived while in the group receiving the drug 17 mice survived. Apply a 2×2 chi-squared test to these data, both with and without Yates's correction, and explain your results.

(10)

After completing the experiment the researcher receives a letter from a colleague detailing the results of a similar experiment he had just completed. In this experiment the viral infection was induced in 144 mice with 72 randomly allocated to the control and active groups respectively. After a 30-day period, 30 mice survived in the control group and 51 in the group receiving the drug treatment. Carry out similar analyses of these data and comment on the results from the two experiments.

(10)

3. To treat patients effectively the drugs prescribed by doctors must have an accurately defined potency. Consequently, the distribution of potency values for shipments of a drug must have a mean value as indicated on the container, and must have a small variance. If this does not happen pharmacists may be distributing drug prescriptions that could be harmfully potent or have low potency and be ineffective. In the marketing leaflet for a particular drug the manufacturer claims that the drug has a potency of 10 milligrams per cubic centimetre (mg/cc) with a standard deviation of 0.04 mg/cc. To investigate the manufacturer's claims a pharmacist selects a simple random sample of ten containers from the latest shipment of the drug and measures the potency of each with the following results:

9.96 9.99 10.05 10.04 9.97 10.06 10.00 10.08 10.07 9.95 .

Test whether the manufacturer's claims concerning the potency of the drug are being met, clearly stating any assumptions on which your analysis depends.

(14)

Determine whether your conclusions would have been the same if the sample had been three times as large with the same sample mean and standard deviation.

(6)

4. A taxi company wishes to investigate whether switching to a new brand of tyre would alter fuel consumption. Ten cars were selected at random from their fleet and driven on two separate occasions over a prescribed test course, once when fitted with the regular brand of tyre and on another occasion, without changing driver, when fitted with the new brand of tyre. The order of the two tests was determined randomly for each car. The petrol consumption in kilometres per litre was recorded on each occasion as follows:

Car	1	2	3	4	5	6	7	8	9	10
New tyre	4.0	4.7	6.6	6.2	4.4	4.0	4.7	4.1	4.2	4.7
Original tyre	4.4	5.0	6.0	7.0	4.6	3.9	5.0	4.5	5.3	4.9

Test the null hypothesis that the type of tyre does not affect fuel consumption using

(i) a sign test,

(7)

(ii) a Wilcoxon signed-rank test.

(10)

Under what circumstances would a parametric test have been more appropriate?

(3)

5. Four different marine paints were compared for their ability to protect ships in a sea-going environment. Sixteen ships were used, each painted with one of the four paints. Each of the ships was deployed for 6 months and on the ship's return a score was assigned according to the amount of chipping, peeling and average remaining paint thickness. A higher score indicated a "better" state of repair. The scores are given in the following table.

Paint 1	80	73	72	90
Paint 2	81	82	88	84
Paint 3	93	80	80	97
Paint 4	89	86	96	99

(i) Carry out a one-way analysis of variance of these data, stating the assumptions you have made and explaining what you conclude as a result of your analysis.

(10)

(ii) After completing the analysis in part (i) you discover that each column of the above table represents a different geographical area in which the ships were deployed. Using this additional information re-analyse the data and comment upon whether your conclusions are affected by this additional information.

(10)

6. A random sample of 100 shops in a particular city was taken and the profit margins (%) were calculated with the following results:

Profit margin (%)	*Number of shops*
0 but less than 2	3
2 but less than 4	8
4 but less than 5	15
5 but less than 6	16
6 but less than 7	17
7 but less than 8	18
8 but less than 10	19
10 but less than 12	3
12 or over	1
Total	100

Draw a histogram depicting the above data.

(8)

Estimate the mean and median profit margins (%), using the above data. Which is the modal class interval?

(8)

You are informed that the mean and median are really 6.42% and 6.41% respectively. Account for any differences of these figures from your answers.

(4)

7. An experiment was performed in which a Geiger counter was used to measure the level of background radiation. In the experiment, radiation counts were made during 100 separate ten-second intervals and the results are summarised in the following table.

Radiation Count	*Number of ten-second intervals*
0	24
1	25
2	18
3	12
4	7
5	9
6	5
>6	0

(i) Investigate the hypothesis that the distribution of radiation counts is Poisson using a chi-squared test.

(8)

(ii) Use a Kolmogorov-Smirnov test to test the hypothesis that the distribution is Poisson with mean 2.

(8)

Comment on your results.

(4)

8. **Gross value added at 1995 basic prices: by industry**
Index numbers

Indices 1995 = 100

	Weight per 1000 in 1995	1989	1990	1991	1992	1993	1994	1995	1996	1997
Manufacturing										
Food; beverages & tobacco	28.7	95.6	97.2	97.0	98.7	99.0	101.5	100.0	101.0	103.4
Textiles & textile products	10.1	112.9	111.8	101.0	101.9	101.3	103.6	100.0	99.6	96.2
Leather & leather products	1.4	116.2	112.1	97.1	94.5	97.8	97.3	100.0	99.9	103.7
Wood & wood products	2.9	115.2	111.6	99.4	98.2	100.4	108.2	100.0	97.6	95.1
Pulp, paper & paper products; publishing, printing	26.3	94.2	96.4	92.0	93.1	96.1	98.5	100.0	98.0	98.3
Coke, petroleum products & nuclear fuel	4.7	81.1	77.4	83.5	88.5	88.9	89.7	100.0	91.8	92.2
Chemicals, chemical products & man-made fibres	24.1	83.6	83.5	85.8	88.5	90.4	95.1	100.0	100.7	101.7
Rubber & plastic products	10.5	85.8	88.2	83.1	85.1	88.9	98.0	100.0	98.8	98.4
Other non-metallic mineral products	7.9	116.7	109.4	99.1	94.7	99.1	102.8	100.0	96.5	99.0
Basic metals & fabricated metal products	24.6	112.1	111.2	101.0	96.0	95.0	97.3	100.0	99.7	101.3
Machinery & equipment not elsewhere classified	19.2	110.1	110.6	98.8	94.8	94.7	99.9	100.0	98.0	95.8
Electrical & optical equipment	26.9	80.0	80.8	77.6	78.9	83.2	93.3	100.0	104.0	105.3
Transport equipment	20.5	111.2	108.8	101.8	99.8	98.1	100.7	100.0	105.7	110.4
Manufacturing not elsewhere classified	7.6	111.1	112.5	98.5	98.0	99.4	102.4	100.0	100.2	101.6
Total manufacturing	215.7	97.9	97.7	92.8	92.8	94.1	98.5	100.0	100.4	101.4

The table above is reproduced from Table 2.4 of *United Kingdom National Accounts 1998*. It shows indices of gross value added in the 14 sections of the manufacturing sector in United Kingdom industries from 1989 to 1997. In 1995, manufacturing accounted for 21.57% of total gross value added in United Kingdom industries.

Write an article for a serious financial or economic weekly newspaper based on this table. Your article should incorporate such diagrams and such statistics calculated from the table as you think appropriate.

(20)