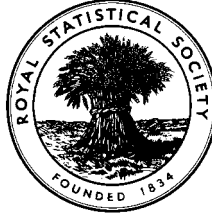# EXAMINATIONS OF THE ROYAL STATISTICAL SOCIETY

(formerly the Examinations of the Institute of Statisticians)

ORDINARY CERTIFICATE IN STATISTICS, 1996

Paper II

Time Allowed: Three Hours

*There is no restriction on the number of questions that a candidate may attempt,
nor on the order in which they are attempted. Candidates are not required
to answer all the questions: they should answer as many as they can.*

*The number of marks allotted to each question is shown in brackets. The total
for the whole paper is 100. A pass may be obtained by scoring at least 50 marks.*

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.*

1. (a) Define the following summary statistics for discrete data:

   (i) mode;
   (ii) median;
   (iii) arithmetic mean.

   (b) As part of an investigation into children's leisure time, 20 girls and 20 boys were asked on how many days in the past week they played with an electronic video game. Their responses, and the summary statistics of these responses, were as follows:

	Mode	Median	Mean
Girls: 0,0,0,0,0,0,0,0,0,0,0,0,1,1,1,1,1,1,2,2	0	0	0.5
Boys: 0,0,0,0,0,0,1,1,1,1,1,2,2,2,3,3,4,4,5,6	0	1	1.8

   Draw two separate bar charts side-by-side to illustrate video game usage by girls and boys separately. Use the same scales on the axes of each diagram.

   (c) In their final summary, the investigators may only use **one** of the above summary statistics to describe the data. They must state this statistic separately for each sex. State one advantage and one disadvantage of using the mode. State one advantage and one disadvantage of using the arithmetic mean. (15)

2. The following table shows the intensity (measured on the Richter scale) of forty major earthquakes that occurred between 1906 and 1976. Display these data in a stem-and-leaf diagram.

   Intensity of forty major earthquakes (measured on the Richter scale)

8.3	8.6	7.5	7.5	8.6	8.3	8.3	7.6	8.9	6.3
8.4	7.5	8.3	7.9	6.0	8.4	7.3	6.8	8.7	7.2
6.8	7.7	7.4	7.1	5.8	8.3	7.1	6.0	8.5	6.9
7.4	7.4	7.7	6.5	6.9	6.2	6.3	6.8	7.5	6.5

   Source: World Almanac and Book of Facts (1977) (8)

Turn over

3. The table below is a cross-classification by political party, by geographical region and by sex of the number of candidates who contested the 1992 British General Election. (Data are only presented for selected regions and political parties. Note that each political party had one candidate in each constituency.) The format of the data is males/females.

Number of candidates who contested the 1992 British General Election

Region	Political party		
	Conservative	*Labour*	*Liberal Democrat*
North West	65/8	57/16	61/12
Midlands	89/11	78/22	85/15
South East	101/8	84/25	81/28
Scotland	63/9	67/5	51/21
Wales	36/2	34/4	30/8

Source: The Independent newspaper, 27 March 1992.

(i) For each region separately, calculate for each party the percentage of constituencies in which there was a female candidate. (8)

(ii) Illustrate your answer to (i) using an appropriate diagram. (8)

(iii) Write a short paragraph to summarise your findings in (i) and (ii). (5)

4. The table given in Question 3 describes the number of male and female candidates in each of three political parties who contested the 1992 British General Election. The format of the data is males/females.

A journalist wishes to interview a sample of fifteen candidates about their experiences during the election campaign. She proposes to randomly select one candidate from each of these three political parties in each of the above regions.

(i) What is the probability that all five Conservative candidates chosen by the journalist will be men ? (2)

(ii) What is the probability that **at least** one of the Conservative candidates chosen by the journalist will be a woman ? (2)

2

(Question continued on next page)

(iii) For the candidates who contested the constituencies in Scotland, what is the probability that **at least** one candidate chosen by the journalist will be a woman ? What is the

equivalent probability for candidates who contested constituencies in Wales ? What is the probability that in **exactly one** of these two cases at least one woman will be chosen? (7)

5. An experiment was performed to investigate the relationship between tensile strength of paper (measured in pounds per square inch) and the percentage of hardwood in the batch of pulp from which the paper was produced. The ten results are shown in the figure below.

Tensile Strength versus Hardwood Concentration
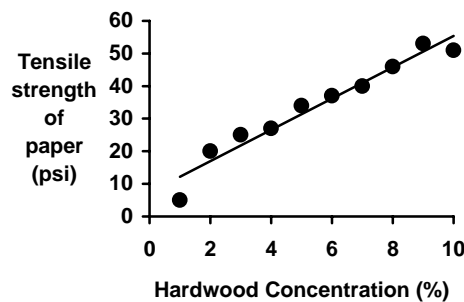
Source: Joglekar G, Schuenemeyer JH and LaRiccia V (1989).

Given that $\sum x = 55$, $\sum x^2 = 385$, $\sum y = 341.5$, $\sum y^2 = 13703.77$, $\sum xy = 2281$

where $x =$ hardwood concentration, $y =$ tensile strength of paper

find the equation of the least-squares regression line of tensile strength of paper on hardwood concentration of pulp.

Estimate the mean increase in tensile strength if the hardwood concentration is increased from 3% to 6%. (8)

3

Turn over

6. The following table shows the estimated sales of jeans (in thousands of pairs) in the United Kingdom between 1982 and 1984.

Estimated Sales of Jeans in the United Kingdom, 1982-84 ('000s of pairs)

Year	Month			
	Jan-Mar	*Apr-Jun*	*Jul-Sep*	*Oct-Dec*
1982	6113	6588	5473	5311
1983	6643	6756	6377	5841
1984	7147	7822	5473	6482

Source: Conrad S (1989).

(i)   Plot the data in the table using the graph paper provided.   (4)

(ii)   Estimate the underlying trend in the sales of jeans using a centred 4 - point moving average. Annotate your diagram in (i) with this trend.   (10)

(iii) By subtracting the underlying trend from the series, estimate the seasonal component of sales.   (5)

(iv)   Briefly describe the pattern of sales of pairs of jeans in the United Kingdom between 1982 and 1984.   (2)

7. Give two advantages of *Laspeyres* indices over *Paasche* indices.

The company Bright Sparks, which produces electric light-bulbs, has three different grades of employee: manufacturing, administrative and managerial. Employees within each grade earn the same salary. The table below shows the salaries and numbers of employees at the beginning of 1995 and 1996.

Salary and Employee Details for Bright Sparks, 1995-96

Employee grade	Salary (£)		Number of employees	
	1 Jan 1995	*1 Jan 1996*	*1 Jan 1995*	*1 Jan 1996*
Manufacturing	9000	9000	500	400
Administrative	13000	13650	70	70
Managerial	25000	30000	50	60

Compute Laspeyres and Paasche salary indices for 1 January 1996, using 1 January 1995 as base.   (10)

8. When plotting the relationship between two variables, where one can naturally be thought of as the dependent variable (*y*) and the other as the independent variable (*x*), it is sometimes desirable to use a logarithmic rather than a linear scale on the *y*-axis.

Give two reasons why a logarithmic scale may be preferred.

(6)