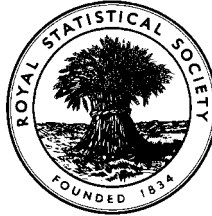**EXAMINATIONS OF THE ROYAL STATISTICAL SOCIETY**

(formerly the Examinations of the Institute of Statisticians)

ORDINARY CERTIFICATE IN STATISTICS, 1997

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) Present the following numbers *correct to 3 significant figures*:

    (i) 54725 (ii) 0.034682 (iii) 600047.91 (3)

   (b) Present the solution to each of the following calculations, correct to the appropriate number of significant figures. For each example, state your reasoning for the number of significant figures quoted.

    (i) $1325 + 670 + 700$
        (where 1325 is an exact figure, 670 has been rounded to the nearest ten units and 700 has been rounded to the nearest hundred units);
    (ii) 1.88×4.3
        (where 1.88 has been rounded to the nearest hundredth of a unit and 4.3 has been rounded to the nearest tenth of a unit). (4)

2. Table 1 summarises the width of a random sample of 100 books from a collector's library.

Table 1: A Random Sample of 100 Books

Book Width (mm)	Frequency
0 -	15
5 -	25
10 -	22
14 -	24
25 -	12
50 - 75	2

   (i) Using the graph paper provided, draw a cumulative frequency curve *(ogive)* of these book widths.

   (ii) From your graph, estimate the median and 10th and 90th percentiles of the distribution of these data. (9)

3. Noting that the data are grouped with unequal class interval widths, estimate the mean and standard deviation of the book widths in Table 1.

(11)

Turn over

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4. A demographer is interested in the relationships between population size and a number of socio–demographic factors in the twelve countries of the European Community in 1991. From published statistics he has constructed Table 2. The layout of the table is poor, however, and does not communicate these data well.

Table 2: Socio–demographic data from the European Community, 1991.

	Country			
	Belgium	*Denmark*	*France*	*Germany*
Population (thousands)	10,004.5	5,154.0	57,055.4	80,013.9
Area (square kilometres)	30,518	43,080	543,965	356,854
Population per square kilometre	327.8	119.6	104.9	224.2
Birth Rate (per 1000 population)	12.5	12.5	13.3	10.4
Death Rate (per 1000 population)	10.4	11.6	9.1	11.4
Persons in employment (thousands)	3,718.6	2,635.2	22,115.3	37,007.3
% Employment in Agriculture	6.4	5.7	6.0	4.2
% Employment in Industry	33.2	27.4	30.0	40.3
	Country			
	Greece	*Ireland*	*Italy*	*Luxembourg*
Population (thousands)	10,200.0	3,523.8	56,760.0	387.1
Area (square kilometres)	131,957	68,895	301,287	2,586
Population per square kilometre	77.3	51.1	188.4	149.7
Birth Rate (per 1000 population)	10.1	15.0	9.8	12.9
Death Rate (per 1000 population)	9.4	8.9	9.6	9.6
Persons in employment (thousands)	3,632.4	1,133.9	21,520.3	162.3
% Employment in Agriculture	22.2	13.9	8.5	3.5
% Employment in Industry	25.7	28.9	32.2	28.9
	Country			
	Netherlands	*Portugal*	*Spain*	*UK*
Population (thousands)	15,067.7	9,861.7	39,024.9	57,790.3
Area (square kilometres)	41,007	91,971	504,790	244,111
Population per square kilometre	367.4	107.2	77.3	236.7
Birth Rate (per 1000 population)	13.2	11.8	10.1	13.7
Death Rate (per 1000 population)	8.6	10.5	8.6	11.1
Persons in employment (thousands)	6,420.3	4,839.4	12,622.1	26,206.9
% Employment in Agriculture	4.3	17.4	10.9	2.3
% Employment in Industry	25.4	34.0	33.0	30.9

Source: Statistical Office of the European Communities (1993).

Describe in detail five changes you would make to the layout of Table 2 in order to improve the visual impact of these data. State your reasoning for each suggested change. (You are not expected to rewrite the table.) (15)

5. Using the data given in Table 2, construct a pie–chart of the area (in square kilometres) of the 12 countries in the European Community in 1991. The smallest four countries may be amalgamated into a single category "Other". (8)

6. A market research company wished to employ a new statistician. As a result of its advertisements the company received a large number of applications.

Applicants were classified by two factors – whether they had previous experience of working for a market research company, and whether they possessed a formal qualification in statistics (such as the RSS Ordinary Certificate).

A proportion P_E of applicants had previous experience of working in market research, and of these, a proportion P_Q possessed a formal statistics qualification. In the remaining applicants with no previous market research experience, two–fifths possessed a formal statistics qualification.

(i) Construct and annotate a *tree diagram* to illustrate the proportions of applicants having previous market research experience and/or possessing a formal statistics qualification. (6)

(ii) (a) Given that one–third of all applicants had *neither* previous market research experience *nor* any formal statistics qualification, calculate P_E.

(b) Given that one–half of all applicants possessed a formal statistics qualification, calculate P_Q.

(c) How many applicants were there in total, if the number of applicants with previous market research experience but no formal statistics qualification was six? (6)

Turn over

7. The heptathlon is a sport in which athletes compete over seven different events. Two events from the heptathlon are the 200 metres sprint and the long jump.

Table 3 shows the performances in the 200 metres sprint and long jump of all 25 competitors in the women's heptathlon at the 1988 Olympic Games. Data for the 200 metres sprint are times measured in seconds, and those for the long jump are distances measured in metres.

Table 3: Olympic women's heptathlon, 1988

Event	Performance (seconds, metres)						
200m sprint	22.56	23.65	23.10	23.92	23.93	24.65	23.59
Long jump	7.27	6.71	6.68	6.25	6.32	6.33	6.37
200m sprint	24.48	24.86	23.59	25.03	23.59	24.87	24.78
Long jump	6.47	6.11	6.28	6.34	6.37	6.05	6.12
200m sprint	24.61	25.00	25.47	24.83	24.92	25.61	25.69
Long jump	6.08	6.40	6.34	6.13	6.10	5.99	5.75
200m sprint	25.50	25.23	26.61	26.16			
Long jump	5.50	5.47	5.50	4.88			

Source: International Athletics Federation (1988).

Summary statistics for these data are:

$$\sum S_i = 616.23, \ \sum J_i = 153.81, \ \sum S_i^2 = 15212.14, \ \sum J_i^2 = 951.70, \ \sum S_i J_i = 3782.28$$

where S_i and J_i denote the ith athlete's performances in the 200 metres sprint and long jump respectively.

(i) Which event's performances have the greater *coefficient of variation*, 200 metres sprint or long jump? (11)

(ii) Using the graph paper provided, draw a scatter–plot of long jump performance versus 200 metres sprint performance. (Present long jump performance on the vertical axis.)

(6)

(Question continued on next page)

(iii) Calculate the product–moment correlation coefficient between performances in the 200 metres sprint and long jump. (3)

(iv) Write a short report to describe performances in the 200 metres sprint and long jump in the women's heptathlon at the 1988 Olympic Games.

(7)

8. Two hotels, Seaview and The Grand, serve the same breakfast to their respective guests each morning. This breakfast comprises fruit juice, cereal, scrambled eggs, toast, marmalade and tea.

Both Seaview Hotel and The Grand Hotel charged £3.50 for this breakfast during 1991. To determine what price to charge during 1992, both hotel managers decided to multiply the above price by some weighted index of the main ingredients' prices (using 1991 as the base year), rounded to the nearest 5 pence.

The manager of Seaview used a *weighted aggregative index*. The manager of The Grand used a *weighted average of price relatives index*.

Table 4 shows the price of each main ingredient in each of the two years and the weights the hotel managers mutually agreed to assign to each ingredient.

Table 4: Prices and relative weights of breakfast ingredients

Breakfast Ingredient	Price (in pence)			Weight
	1991	1992		
Fruit Juice	84.7	82.4	(per litre)	5
Cereal	223.5	239.5	(per kg)	25
Milk	55.1	56.3	(per litre)	5
Eggs	9.2	9.3	(per egg)	15
Brown Bread	89.1	89.2	(per kg)	10
Butter	239.9	246.8	(per kg)	5
Marmalade	154.5	162.0	(per kg)	15
Tea	514.1	501.0	(per kg)	20

Source of prices: UK National Food Survey (1992)

Calculate the price of breakfast in each of the two hotels during 1992. In which hotel was breakfast more expensive during 1992 ? (11)

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