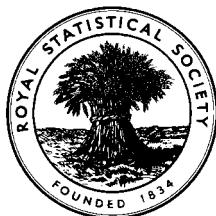# EXAMINATIONS OF THE ROYAL STATISTICAL SOCIETY
(formerly the Examinations of the Institute of Statisticians)

ORDINARY CERTIFICATE IN STATISTICS, 1999

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 or part-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

1. (a) Explain the distinction between a ratio and a rate. Give one example of each type of number.

(4)

(b) Table 1 shows the total numbers of cinema admissions in ten different European countries during the year 1996. Each total is sub-divided by the country of origin of the film attended; whether the film originated from the same country (labelled "domestic") or from another country (labelled "foreign"). Also included are the average prices of cinema admission (in ECUs) and population of each country during the same year.

Table 1. Cinema attendance in 10 European countries during 1996.

Country	Number of admissions ('000's)			Average price of admission (ECUs)	Population ('000s)
	Domestic films	Foreign films	All films		
Belgium	1061	20031	21092	4.99	10143
Denmark	1677	8200	9877	4.79	5251
Finland	586	4955	5541	6.17	5117
France	51481	86231	137712	5.30	58256
Germany	20160	112920	133080	5.11	81817
Italy	22445	69104	91549	4.81	57333
Netherlands	966	15955	16921	5.12	15494
Spain	9284	94960	104244	3.25	39242
Sweden	2983	12439	15422	7.17	8837
United Kingdom	12970	111166	124136	4.33	58694
All countries	123613	535961	659574	4.72	340184

Source: European Cinema Yearbook (1997)

Calculate for each country separately, and for 'all countries' in total:

(i) the percentage of all admissions to domestic films (to 1 decimal place),

(ii) the mean numbers of admissions per head of population to domestic films, foreign films and all films respectively (to 2 decimal places).

(12)

2. Present the data in your answer to question 1(b)(ii) using a suitable chart. State two advantages of this type of diagram compared to an alternative diagram that might have been chosen to illustrate these data.

(13)

3

Turn over

3. The following Spearman rank-correlation coefficients have been computed:

    (i)   between the mean number of admissions per head of population to domestic films and the average price of cinema admission = 0.09;

    (ii)   between the mean number of admissions per head of population to foreign films and the average price of cinema admission = -0.65;

    (iii)   between the mean number of admissions per head of population to domestic films and the mean number of admissions per head of population to foreign films = 0.03.

    Show how the *first* of these correlation coefficients was calculated.

                                                                                                    (6)

4. Write a report of 200-300 words in which you describe and compare the different patterns of cinema attendance in ten European countries during 1996.

    (Note: do not include any extra tables or diagrams in your report. Refer only to the data contained in table 1 and the summary statistics and diagrams you have already presented for questions 1 to 3.)

                                                                                                    (12)

5. Mr Smith attempts the quiz that appears each day in his favourite newspaper. Every day's questions are different, although the format of the quiz stays the same. There are three multiple-choice questions labelled 'easy', 'moderate' and 'difficult'. Each question has three possible answers given, only one of which is correct.

    From previous quizzes, Mr Smith knows that he has a probability of 2/3 of answering the 'easy' question correctly and a probability of 1/5 of answering the 'difficult' question correctly. He is equally likely to answer the 'moderate' question correctly or incorrectly. The event that he answers a question correctly is independent of his answers to other questions.

    (i)   What are the probabilities that Mr Smith will answer a total number of exactly zero, one, two and three questions correctly?

                                                                                                    (9)

    (ii)   Draw a pie diagram to illustrate the probabilities you calculated in part (ii), indicating the angles, in degrees, at the centre of the circle.

                                                                                                    (7)

6. The British Broadcasting Corporation (BBC) operates seven national television and radio stations in the United Kingdom. Table 2 shows the number of hours of programmes broadcast by the BBC on each station during 1994-95, along with their annual average costs (in £ 000s).

Table 2. BBC broadcasting hours and costs, 1994-95.

Station	Number of hours of programmes		Average cost (£000s) per hour of programme	
	1994	*1995*	*1994*	*1995*
Television				
BBC1	6843	6835	112	117
BBC2	6960	7471	89	86
Radio				
R1	8723	8784	2.6	2.7
R2	8735	8784	3.8	3.6
R3	6728	6861	7.1	7.4
R4	7449	7611	10.2	10.5
R5	8740	8784	3.1	3.3

Source: BBC Annual Report (1996)

(i) Calculate the weighted average cost per hour of transmission for 1995, weighting by the number of hours of programmes broadcast by each station. Express your answer as the cost per hour to the nearest £.

(5)

(ii) Compute Laspeyres price indices for 1995 with 1994 as base year, to determine which of television or radio had the greater relative increase in cost.

(7)

Turn over

7. The percentage of body fat in an individual can be estimated in a number of ways. One method is by a combination of underwater weighing and the measurement of various body circumferences. Table 3 contains estimates of percentage of body fat obtained by that method for a random sample of 20 men aged 22-35 years.

Table 3. The percentage of body fat in 20 young men.

12.9	28.7	4.1	20.8	29.0	6.1	20.9	11.7	21.2	22.9
25.3	19.2	7.1	22.1	16.0	10.4	12.4	7.8	20.9	16.5

Source: Penrose, Nelson and Fisher (1985)

(a) Calculate the mean, standard deviation and coefficient of variation of the percentage of body fat in these men.

(7)

(b) Using the percentage of body fat as an example, explain the distinction between inter- and intra-subject variation in measurement. Discuss one reason why you might report each type of variation separately in a survey report.

(6)

8. Data in table 4 aim to describe the flow of the Fraser River at Hope, British Columbia, in regular bimonthly intervals from January 1979 to December 1981. Also contained are the underlying trend values for these data calculated by centred six point moving average.

(Note: Trend values for January-June 1979 and July-December 1981 are calculated using data not shown here.)

Table 4. The flow of the Fraser River at Hope, British Columbia, 1979-81.

Year		*Bimonthly mean river flow (cm)*					
		Jan-Feb	Mar-Apr	May-Jun	Jul-Aug	Sep-Oct	Nov-Dec
1979	Data	835	1455	4840	3755	2345	1300
	Trend	*2377*	*2367*	*2409*	*2415*	*2382*	*2420*
1980	Data	760	1125	5635	3735	1625	935
	Trend	*2485*	*2423*	*2333*	*2295*	*2295*	*2252*
1981	Data	665	1230	5010	6730	2340	1765
	Trend	*2450*	*2759*	*2888*	*3040*	*3154*	*3234*

Adapted from I McLeod (1994), via StatLib (http://lib.stat.cmu.edu/datasets)

Assuming an *additive* model for these data,

(i) estimate the seasonal component of river flow,

(ii) determine for which months of 1981, if any, the residual component of river flow exceeded 400 cm in magnitude.

(12)