

OXFORD CAMBRIDGE AND RSA EXAMINATIONS
Advanced Subsidiary General Certificate of Education

MEI STATISTICS

G243

Statistics 3 (Z3)

Thursday **15 JUNE 2006** Afternoon 1 hour 30 minutes

Additional materials:
8 page answer booklet
Graph paper
MEI Examination Formulae and Tables (MF2)

TIME 1 hour 30 minutes

INSTRUCTIONS TO CANDIDATES

- Write your name, centre number and candidate number in the spaces provided on the answer booklet.
- Answer **all** the questions.
- You are permitted to use a graphical calculator in this paper.
- Final answers should be given to a degree of accuracy appropriate to the context.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets [] at the end of each question or part question.
- You are advised that an answer may receive **no marks** unless you show sufficient detail of the working to indicate that a correct method is being used.
- The total number of marks for this paper is 72.

This question paper consists of 5 printed pages and 3 blank pages.

Section A (45 marks)

- 1 Agricultural scientists are studying the relationship between the yield of a crop and the amount of rainfall. Data from a random sample of 9 farms give the following values of y , the yield of the crop measured in a convenient standard unit, and x , the rainfall during the growing season measured in mm.

Farm	A	B	C	D	E	F	G	H	I
x	152	74	96	310	248	105	140	186	161
y	26.4	18.8	21.3	37.0	34.6	18.0	26.7	31.2	29.0

- (i) Draw a scatter diagram to illustrate these data, and comment on it briefly. [5]
- (ii) Calculate the value of Spearman's rank correlation coefficient. [4]
- (iii) Hence test at the 5% level of significance whether it is reasonable to assume that rainfall and yield are associated. [3]
- (iv) Give a reason, referring to your scatter diagram, why you might be unwilling to base a test on the value of the product moment correlation coefficient for these data. If you were to carry out such a test, what null hypothesis would you be testing? [3]
- 2 A study is being made of towns in two large areas, A and B, as part of a comparison of overall residential attractiveness. Each area has many towns and it is not practicable to include them all in the study. A sample of 8 towns is selected from area A and a sample of 10 from area B. Each is regarded as a random sample from a suitably defined underlying population.
- (a) (i) One of the criteria is accessibility to transport links. A transport analyst ranks the 18 towns in order of this accessibility (rank 1 denoting the most accessible). The ranks are as follows.
- | | | | | | | | | | | |
|-----------------|---|---|---|---|---|----|----|----|----|-------|
| Towns in area A | 1 | 2 | 4 | 5 | 6 | 10 | 11 | 13 | | |
| Towns in area B | | 3 | 7 | 8 | 9 | 12 | 14 | 15 | 16 | 17 18 |
- Test at the 5% level of significance whether, on the whole, the two areas may be assumed equivalent in this regard, stating your null and alternative hypotheses. [8]
- (ii) Comment very briefly on why this part of the study was conducted as a ranking exercise, and state one drawback of this. [2]
- (b) Another criterion is air pollution. The pollution level is measured for each town in the samples. Underlying Normality may be assumed. A statistician wishes to compare the means for the two areas by carrying out a two-sample test.
- (i) The statistician uses a test based on the Normal distribution. What further information does he need when calculating the value of the test statistic? [2]
- (ii) The value of the test statistic is 1.82. Carry out the test, using a 5% significance level and a two-sided interpretation, giving your conclusion. [3]

- 3 (i) Describe the circumstances when systematic sampling might sensibly be used as a method for selecting a sample for a survey. [2]

A Psychology Department at a university has 96 first-year students. There is a list of them in alphabetical order. A sample of size 12 is required for a survey.

- (ii) Describe how this sample could be selected by systematic sampling. [2]

The survey is concerned with overall academic ability and aptitude during the transition from school to university. The 12 selected students take two tests, one on entering the university and the other after three months. The 12 students are regarded as a random sample from the student population. The scoring systems for the tests have been designed so that, on the whole, equivalent performances in the two tests should result in equal scores and improved performance should result in a higher score. Underlying Normality may be assumed, as appropriate.

- (iii) The students' scores are as follows.

Student	A	B	C	D	E	F	G	H	I	J	K	L
First test	400	371	365	529	346	371	414	286	453	320	314	265
Second test	438	389	437	558	334	470	437	327	451	366	366	327

Use a t test to examine, at the 5% level of significance, whether it appears that the mean score for students in the second test is greater than that for the first. State carefully your null and alternative hypotheses and your conclusion. [11]

[Question 4 is printed overleaf.]

Section B (27 marks)

- 4 Engineers at a chemical company are trying to improve the performance of a process for making a particular type of plastic. The yield of the plastic is affected by the pressure and temperature in the reaction chamber in which it is made. The engineers hope that changing the pressure or the temperature, or both of them, will improve the average yield. However, they fear that such changes might increase the variability of the yield.

The process currently runs at temperature 550 °C and at pressure 2.6 units.

- (i) The engineers carry out an experiment with four trial runs with settings as follows.

Run A: pressure 2.2, temperature 500 °C.
 Run B: pressure 3.0, temperature 500 °C.
 Run C: pressure 2.2, temperature 600 °C.
 Run D: pressure 3.0, temperature 600 °C.

Give a reason why the design of this experiment appears sensible for investigating whether the average yield can be improved, assuming there is no change in variability. [2]

Give a reason why the design of this experiment is not suitable for investigating whether the variability of yield has changed. [2]

The engineers establish that the best pressure is 2.6 and the best temperature is 625 °C. All future experiments are carried out at this pressure and this temperature.

The company's factory has two reaction chambers in which the process can be run, and the next task is to establish whether or not these two chambers perform similarly in terms of the average yield of the plastic.

- (ii) The engineers carry out a further experiment. They undertake five trial runs in one chamber, one run on each day of a working week. The next week, they similarly undertake five trial runs in the other chamber. The yields, in kg, of the plastic are as follows.

First chamber	26.8	28.4	27.1	21.9	30.6
	Sample mean $\bar{x} = 26.96$				
	Sample variance $s_1^2 = 10.243$				
Second chamber	23.2	22.5	20.9	28.6	29.4
	Sample mean $\bar{y} = 24.92$				
	Sample variance $s_2^2 = 14.647$				

Assuming that the underlying variances for the two chambers are the same, test the null hypothesis $\mu_1 = \mu_2$, where μ_1 and μ_2 are the population mean yields for the two chambers, against the alternative $\mu_1 \neq \mu_2$, at the 5% level of significance, stating your conclusion carefully. [10]

The company statistician suggests that yields may be affected by day-to-day variability in the quality of the raw materials supplied to the factory.

- (iii) Explain why the experiment in part (ii) is unsatisfactory. Explain how a paired comparison experiment could be carried out in this context and why it would be an improvement. [4]

[Question 4 continues on the next page.]

The statistician also suggests that the assumption of underlying Normality that was needed for the test in part (ii) may not be valid. The engineers therefore carry out a new experiment according to a paired comparison design, and ask the statistician to analyse the data.

(iv) The data are as follows. There are 10 paired trials, labelled I, II, ..., X.

Trial	I	II	III	IV	V	VI	VII	VIII	IX	X
Yield (kg) in first chamber	29.4	28.0	27.8	24.2	26.9	30.0	23.4	21.8	21.7	31.0
Yield (kg) in second chamber	29.0	28.5	26.6	24.5	26.2	28.0	23.5	21.2	20.2	30.0

Use the Wilcoxon signed rank test, at the 5% level of significance, to examine whether the underlying medians may be assumed equal. [9]

**ADVANCED SUBSIDIARY GCE UNIT
MEI STATISTICS**

G243/01

Statistics 3 (Z3)

MONDAY 18 JUNE 2007

Morning

Time: 1 hour 30 minutes

Additional Materials:
Answer booklet (8 pages)
Graph paper
MEI Examination Formulae and Tables (MF2)

INSTRUCTIONS TO CANDIDATES

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ADVICE TO CANDIDATES

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This document consists of **4** printed pages.

Section A (45 marks)

- 1 Scientists at a horticultural research laboratory are comparing two types, A and B, of a particular flower in terms of the intensity of its colour. The intensity is rated on a continuous scale. 10 flowers of each type are planted in an experimental field. A paired arrangement is used, with a type A and a type B flower planted near to one another in each of ten positions scattered around the field.

- (i) Suggest why a paired arrangement has been used. [2]
- (ii) The intensity ratings are as follows.

Position in field	I	II	III	IV	V	VI	VII	VIII	IX	X
Type A	35.3	36.2	33.2	28.1	37.9	30.9	38.8	29.3	30.6	38.8
Type B	31.6	34.8	35.8	28.7	37.5	31.9	38.6	27.2	30.7	38.1

Stating an appropriate assumption about underlying Normality, use a t test to examine, at the 10% level of significance, whether it appears that the mean ratings for the two types are the same. State carefully your null and alternative hypotheses and your conclusion. Name a test which could be used if no assumption of underlying Normality could reasonably be made. [13]

- 2 Traffic engineers are studying the correlation between traffic flow on a busy main road and air pollution at a nearby air quality monitoring station. Traffic flow is recorded automatically by sensors and reported each hour as the average flow in vehicles per hour for the preceding hour. The air quality monitoring station provides, each hour, an overall pollution reading in a suitable unit (higher readings indicate more pollution). Data for a random sample of 15 hours are as follows.

Traffic flow x	1815	2206	1835	1918	2420	2315	1796	2850
Pollution y	3.5	8.3	5.0	4.8	20.0	18.0	3.6	32.0

Traffic flow x	2635	2588	2040	2368	2170	2285	2120
Pollution y	24.2	24.4	9.5	16.2	10.6	13.8	12.0

- (i) Draw a scatter diagram to illustrate these data, and comment on it briefly. [4]
- (ii) Calculate the value of the product moment correlation coefficient. [2]
- (iii) What assumption about the underlying population is required for it to be valid to carry out the usual test based on the product moment correlation coefficient? Discuss briefly whether it appears reasonable, from the scatter diagram, to suppose that this assumption holds. [2]
- (iv) Supposing that the assumption in part (iii) does hold, test at the 1% level of significance whether it is reasonable to suppose that there is a positive correlation between traffic flow and air pollution. State carefully the null hypothesis you are testing. [5]
- (v) The local newspaper carries a headline “Heavy traffic causes air pollution”. Comment briefly on this headline in the light of your results. [2]

- 3 Environmental scientists are investigating the heights of tides at two seaside towns as part of a study to see whether either appears more vulnerable to flooding than the other. A common baseline level is established and, at each town, an automatic measuring device gives a reading for the height of each tide above this level. Results for a random sample of 10 tides at town A and a separate random sample of 12 tides at town B are as follows, the units being metres.

Town A	1.4	4.4	2.1	0.7	5.4	3.7	2.6	0.2	0.9	3.8		
Town B	2.7	0.6	5.9	4.0	3.6	5.6	4.2	5.5	5.1	4.6	5.7	3.9

- (i) It is desired to see whether, on average, the heights at the two towns are the same. However, it is not thought appropriate to assume Normality of the underlying populations. State null and alternative hypotheses that can be investigated and carry out a suitable test at the 5% level of significance. [10]
- (ii) Discuss whether it appears sensible to have used two separate random samples
- (A) if the towns are within a few miles of each other on the same stretch of coastline,
- (B) if one of the towns is on the east coast of the country and the other on the west. [5]

[Question 4 is printed overleaf.]

Section B (27 marks)

- 4 Market researchers are advising a cosmetics company whether a product should be introduced into a region where it is not currently widely available. The company wants to know how attractive the product is likely to be to the population.

(i) Discuss issues that arise in defining ‘the population’ in this context. [4]

As part of the work, the researchers decide to carry out a survey of female sixth-form students attending schools or colleges in the region. There are many such schools and colleges and a large number of such students.

(ii) Describe briefly how cluster sampling might be carried out in this situation. [2]

(iii) Why might cluster sampling be a better way to proceed than simple random sampling over all the schools and colleges? [2]

(iv) Explain why cluster sampling would be unwise if some of the students attend schools with sixth forms, some attend sixth-form colleges, and others attend further education colleges. What sampling method would be more appropriate? [3]

A researcher forms a testing panel consisting of a random sample of 7 female students from one sixth-form college and a random sample of 10 from another.

(v) Each member of the panel is asked to rate the overall attractiveness of the product on a numerical scale. The ratings are summarised as follows.

College A	$n = 7$	Sample mean = 68.6	Sample variance = 9.28
College B	$n = 10$	Sample mean = 64.2	Sample variance = 12.16

Assuming underlying Normality, test at the 5% level of significance whether the mean rating for the population in college A may be taken as the same as that in college B. What else do you need to assume when carrying out this test? [11]

(vi) The sample of 7 female students from college A was in fact selected by systematic sampling. Altogether there are 420 female students in the college. Describe how the systematic sampling could have been undertaken. Discuss whether systematic sampling in this situation might reasonably be assumed to be equivalent to simple random sampling. [5]

**ADVANCED SUBSIDIARY GCE
MEI STATISTICS**

G243/01

Statistics 3 (Z3)

MONDAY 2 JUNE 2008

Morning
Time: 1 hour 30 minutes

Additional materials: Answer Booklet (8 pages)
Graph paper
MEI Examination Formulae and Tables (MF2)

INSTRUCTIONS TO CANDIDATES

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Section A (45 marks)

1 The manager of a large shopping precinct has commissioned a survey of customers. A sample of customers leaving the precinct one morning are to be interviewed and asked how far they have travelled to get to the precinct and how much money they have spent there.

(i) Each interviewer is instructed to interview twenty adult males (age between 20 and 60), twenty adult females, ten teenage males, ten teenage females and fifteen senior citizens (age 60 or above). What form of sampling is this? Give an advantage and a disadvantage of carrying out the sampling in this way. [3]

(ii) In addition, each person in a simple random sample of 20 customers in the precinct's cafeteria is asked the same questions. The results are as follows.

Distance travelled (miles)	0.2	0.3	0.8	1.0	1.1	1.8	2.3	2.4	2.9	3.6
Money spent (£)	4.6	66.2	4.0	25.5	20.6	4.5	55.8	8.0	7.5	36.4
Distance travelled (miles)	4.1	4.8	5.0	5.1	5.3	8.0	9.4	11.6	13.8	15.2
Money spent (£)	12.0	30.0	6.3	46.6	68.3	60.0	72.5	34.2	65.7	65.0

(A) Draw a scatter diagram to illustrate these data. [3]

(B) Calculate the value of Spearman's rank correlation coefficient and hence test at the 5% level of significance whether there appears to be any association between distance travelled and money spent for the underlying population of such customers. [7]

(C) The manager suggests that the test should instead be based on the product moment correlation coefficient. Explain whether or not you agree with this suggestion. [2]

2 Industrial quality control engineers are studying the output of steel rods made by two machines. It is accepted that, for each machine, there is some variability in the lengths of the rods, but the two machines should make rods of the same length on average. The lengths x , in metres, of large random samples of rods made by each machine are measured; the results are summarised as follows.

Machine A	Sample size $n_1 = 90$	$\Sigma x = 184.5$	$\Sigma x^2 = 396.94$
Machine B	Sample size $n_2 = 75$	$\Sigma x = 156.0$	$\Sigma x^2 = 334.19$

(i) Test, at the 10% level of significance, whether the two machines are making rods with the same length on average, stating carefully your null and alternative hypotheses and your conclusion. [13]

(ii) Explain briefly why it is not necessary to make any assumption of Normality for the underlying populations. [2]

- 3 Two airlines compete on a route from one city to another. Two businessmen who both make the journey on Tuesday of each week agree to compare the two airlines by noting their total journey times, including checking-in, waiting in the departure lounge and collecting luggage after arrival. One businessman uses one airline, and the other uses the other. Their total journey times, in minutes, for a random sample of 10 weeks are as follows.

Week	A	B	C	D	E	F	G	H	I	J
First airline	121	114	138	110	92	98	92	104	101	115
Second airline	107	98	132	118	116	86	90	119	91	116

- (i) Use the Wilcoxon signed rank test, at the 5% level of significance, to examine whether the underlying median journey times may be assumed equal. [9]
- (ii) Explain why it is sensible for a 'paired comparisons' experiment to have been carried out by the businessmen. [2]
- (iii) Briefly discuss **two** other features of the situation that the businessmen might take into consideration. [4]

[Question 4 is printed overleaf.]

Section B (27 marks)

- 4 Scientists at an agricultural research station are developing two new varieties, A and B, of a particular crop. They wish to compare these new varieties with each other and with the existing standard variety, V.

The research station has an experimental field that is divided into plots, all of the same size, on which the crop can be grown under controlled conditions. However, the natural fertility of the soil in the field varies somewhat from place to place and depending on its previous use, so some plots may be naturally more fertile than others.

- (i) Explain why it is sensible to allocate the varieties A, B and V to the plots in the field in a random way. [2]
- (ii) Explain why each of the varieties should appear more than once in the allocation. [2]

Initially the scientists compare the two new varieties, A and B, with each other. 6 of the plots in the field had received variety A and 5 had received variety B. Their yields, in kg per plot, were as follows.

Variety A	24.1	23.3	21.8	24.6	23.7	23.5
Variety B	20.8	22.4	21.6	23.1	21.8	

- (iii) Stating carefully the required assumptions and the null and alternative hypotheses, use a t test to examine, at the 5% level of significance, whether the mean yields of the two varieties may be assumed to be the same. [15]

Development of variety B is discontinued. The scientists design a further experiment to compare A with V, in which plots of A and V are used alongside each other at each of a number of locations around the field.

- (iv) Explain why this design should be expected to achieve a more precise comparison of A with V than using plots of A and V in random locations around the field. [2]
- (v) This experiment has 5 locations where A and V are used alongside each other. Making the appropriate distributional assumption, the scientists examine whether the overall mean yield of A appears to be greater than that of V by calculating the value of the usual t statistic for this situation; they find this value to be 1.91. Complete the test, using a 5% level of significance, and state your conclusion. State the distributional assumption the scientists made. [6]

ADVANCED SUBSIDIARY GCE
MEI STATISTICS
Statistics 3 (Z3)

G243

Candidates answer on the Answer Booklet

OCR Supplied Materials:

- 8 page Answer Booklet
- Graph paper
- MEI Examination Formulae and Tables (MF2)

Other Materials Required:

None

Thursday 11 June 2009
Morning

Duration: 1 hour 30 minutes



INSTRUCTIONS TO CANDIDATES

- Write your name clearly in capital letters, your Centre Number and Candidate Number in the spaces provided on the Answer Booklet.
- Use black ink. Pencil may be used for graphs and diagrams only.
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Section A (47 marks)

- 1** For a piece of coursework in psychology, students were asked to analyse reaction times. One student found a piece of software on the internet that measures the time taken to react to a stimulus by pressing a key. She used this with a random sample of 10 friends, recording times, in milliseconds, for their non-dominant and dominant hands. The data were recorded as follows.

Friend	Non-dominant	Dominant
1	485	336
2	356	381
3	450	348
4	402	329
5	376	329
6	409	346
7	419	344
8	289	327
9	420	342
10	410	356

- (i) Use a t test to investigate whether people have a shorter reaction time, on average, with their dominant hand. Use a 5% level of significance and state your hypotheses clearly. State the required distributional assumption for the test to be valid. **[14]**
- (ii) Explain why the student should not measure the times taken with non-dominant and dominant hands in the same order for all the 10 friends. **[2]**

- 2 A nationally known retailer is investigating the effectiveness of its TV advertising. In the North-West, the retailer ran a major TV advertising campaign late in 2008. The sales (£ thousands) for January to March 2009 in a random sample of 10 of its stores in the North-West are as follows, listed in ascending order.

2159 2361 2570 2985 3012 5442 5756 5825 6023 6078

- (i) Suggest why it might not be appropriate to compare these data with corresponding sales figures for January to March 2008. [1]

From historical data, the retailer believes that sales at its stores in the North-East are generally comparable with those in the North-West. However, there was no advertising campaign in the North-East.

A random sample of 8 stores in the North-East gives the following sales figures (£ thousands) for January to March 2009, listed in ascending order.

1951 2077 2193 2286 2780 2983 4912 5629

- (ii) Use a suitable test, at the 5% significance level, to examine whether the median sales figure in the North-West for this period is greater than that in the North-East. What does your conclusion suggest about the effectiveness of the TV advertising campaign? [11]

- (iii) The retailer has 30 stores in the North-East. Explain how to choose a random sample of 8 of these stores. [4]

- 3 In the course of a medical treatment, random samples of male and female patients have their temperatures, x °C, recorded. For the 36 males, the mean is 36.8 °C and the standard deviation is 0.247 °C. For the 34 females, $\Sigma x = 1252.9$ and $\Sigma x^2 = 46\,172.85$.

- (i) Calculate the mean and standard deviation for the females. [3]

A doctor uses these data to test whether there is a difference between the population mean temperatures of males and females undergoing this treatment.

- (ii) Explain why it is appropriate to use a test based on the Normal distribution in this case. [1]

- (iii) Carry out the test, at the 1% level of significance, stating your hypotheses. [11]

[Question 4 is printed overleaf.]

Section B (25 marks)

- 4 For employees working in a noisy environment, companies arrange for annual hearing tests in order to monitor whether hearing function decreases with years of service. Data for a random sample of 10 such employees, for one company, are given in the following table.

Employee	A	B	C	D	E	F	G	H	I	J
Years of service	12	3	27	5	2.5	4	8	9	10	14
% Hearing function	90	91	84	97	92	94	88	85	98	89

- (i) Draw, on graph paper, a scatter diagram of these data. [3]
- (ii) The product moment correlation coefficient for these data is $r = -0.5711$. Test at the 5% level of significance whether or not there is negative correlation between years of service and hearing function in the underlying population. State your hypotheses clearly. [6]
- (iii) Explain why it might not be appropriate to carry out a test based on the product moment correlation coefficient for these data. [2]
- (iv) Calculate Spearman's coefficient of rank correlation between years of service and hearing function. [4]
- (v) Conduct a hypothesis test based on this new coefficient, stating your hypotheses clearly. [4]
- (vi) Comment on the outcomes of the two tests. [2]
- (vii) In order to focus further research, suggest two other factors that might affect hearing function, apart from years of service. [2]
- (viii) Another company, operating on six sites, wishes to select a sample of employees for hearing tests, ensuring that each site is represented in the sample. Explain why simple random sampling would not be appropriate. Suggest a sampling method that would be appropriate. [2]

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ADVANCED SUBSIDIARY GCE
MEI STATISTICS
Statistics 3 (Z3)

G243

Candidates answer on the Answer Booklet

OCR Supplied Materials:

- 8 page Answer Booklet
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- MEI Examination Formulae and Tables (MF2)

Other Materials Required:

- Scientific or graphical calculator

Tuesday 15 June 2010
Morning

Duration: 1 hour 30 minutes



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Section A (45 marks)

- 1 A student measures the pulse rates of a random sample of 10 runners both before and after they have run round an athletics track. The pulse rates are as follows.

Runner	A	B	C	D	E	F	G	H	I	J
Before	83	75	73	80	88	61	70	77	76	62
After	148	100	98	171	152	94	127	132	170	106

- (i) Draw a scatter diagram to illustrate these data. [3]
- (ii) Calculate the value of the product moment correlation coefficient. [2]
- (iii) Carry out a hypothesis test at the 1% significance level to determine whether there appears to be positive correlation between pulse rate before exercise and pulse rate after exercise, stating your hypotheses. [6]
- (iv) State the distributional assumption which is necessary for this test to be valid. Explain briefly in the light of the scatter diagram why it appears that the assumption may be valid. [2]
- (v) If this distributional assumption is not valid, what alternative test procedure could be performed? If you were to carry out this test, what null hypothesis would you be testing? [2]
- 2 Carrots are supplied to a supermarket chain by two different suppliers. The weights, x grams, of random samples of carrots from each supplier are summarised as follows.

Supplier A	Sample size $n_A = 100$	$\Sigma x_A = 10\,313$	$\Sigma x_A^2 = 1\,072\,660$
Supplier B	Sample size $n_B = 95$	$\Sigma x_B = 9\,672$	$\Sigma x_B^2 = 986\,540$

- (i) Carry out a test at the 1% significance level to determine whether carrots supplied by the two suppliers have the same mean weight, stating your hypotheses and your conclusion. [12]
- (ii) Explain why it is valid to carry out this test without knowing the population variances. [2]
- (iii) Assuming that the population mean weights are the same, explain why the supermarket chain might prefer carrots from supplier B. [1]

- 3 A researcher is investigating the speed of shipping in the English Channel. She records the speeds in knots of a random sample of 13 tankers and 15 general cargo vessels. The results, given in ascending order, are as follows.

Tanker	5.9	8.3	8.5	9.5	10.9	11.1	11.2	11.5	12.6	13.4	13.7	13.9	15.1		
General cargo vessels	9.6	10.6	11.3	12.0	12.5	12.7	13.1	13.2	13.5	13.8	14.5	16.1	16.7	17.0	24.4

The researcher wishes to investigate whether, on average, the speeds of tankers and the speeds of general cargo vessels are the same. The underlying populations are not considered to be Normally distributed.

- (i) State suitable null and alternative hypotheses for a test which can be performed to investigate whether, on average, the speeds are the same. Carry out the test at the 5% significance level. [10]
- (ii) Name a test which could be performed if the population distributions were Normal. What property of the variances of the two populations is required to perform this test? [3]
- (iii) If, instead, the numbers of tankers and general cargo vessels in the sample were the same, would it be appropriate to carry out a signed rank test? Briefly explain your answer. [2]

[Question 4 is printed overleaf.]

Section B (27 marks)

4 As part of a large construction project, over the course of three weeks a large number of lorries deliver liquid concrete to the project site. In order to check the quality of the concrete, a number of samples of concrete are selected. For each sample, a small quantity of liquid concrete is taken from a lorry and left to harden. It is then tested for compressive strength.

(i) Explain what population is being sampled in this case. [2]

The project engineer considers a number of methods of conducting the sampling.

- Choose a single day and sample all of the lorries which arrive on that day.
- Sample the first lorry which arrives on each day.
- On each day, select a lorry at random from the lorries due to arrive on that day.

(ii) Comment briefly on whether each of these methods is likely to result in a representative sample. [3]

(iii) If there were a list of all of the concrete deliveries expected at the site during the three weeks, explain briefly how a simple random sample of size 15 could be selected. [3]

The concrete is supplied by two different companies, A and B. The project engineer wishes to test whether there is any difference in the mean compressive strength of the concrete supplied by the two companies. The sampling process results in 9 samples from Company A and 6 samples from Company B. The compressive strengths, measured in suitable units, are summarised as follows.

Company A	$n = 9$	Sample mean 4.210	Sample standard deviation 0.2482
Company B	$n = 6$	Sample mean 4.295	Sample standard deviation 0.2459

(iv) State appropriate null and alternative hypotheses for a t test to determine whether there is any evidence that the mean compressive strengths of the concrete from the two companies are different. An assumption required for this test is equality of population variances. What other distributional assumption is required? Carry out the test at the 5% level. [13]

At a later stage in the project, a further large quantity of concrete is required. The project engineer again checks the quality of the concrete from each company. For a period of 10 days he takes two samples per day, one from a lorry belonging to Company A and one from a lorry belonging to Company B. He suspects that the weather conditions on each day may have an effect on the quality of the concrete. He wishes to check if the mean compressive strengths of the concrete supplied by the two companies are equal.

(v) Explain briefly why a paired t test should be carried out in this situation. [2]

(vi) The project engineer carries out a paired t test. He calculates the usual t statistic for this situation and finds this value to be 2.31. Complete the test, using a 5% significance level, stating your conclusion clearly. [4]

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ADVANCED SUBSIDIARY GCE

MEI STATISTICS

Statistics 3 (Z3)

G243

QUESTION PAPER

Candidates answer on the printed answer book.

OCR supplied materials:

- Printed answer book G243
- MEI Examination Formulae and Tables (MF2)

Other materials required:

- Scientific or graphical calculator

Thursday 16 June 2011

Afternoon

Duration: 1 hour 30 minutes

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Section A (45 marks)

- 1 An advertisement claims that ‘brain training’ increases scores in word-matching games. A psychologist decides to investigate this claim. A random sample of 10 people is selected and all of them play the same word-matching game. After one month of doing brain training exercises, these 10 people repeat the word-matching game.

Player	A	B	C	D	E	F	G	H	I	J
Score before brain training	62	56	36	52	58	94	76	58	62	64
Score after brain training	76	54	53	47	48	87	91	62	71	83

- (i) Explain why the psychologist has used a paired design. [2]
- (ii) Use the Wilcoxon signed rank test, at the 5% level of significance, to examine the claim. [9]
- (iii) The psychologist originally planned to carry out a paired sample t test. However, she decided that the distributional assumption required for this test might not have been satisfied. State this assumption and briefly explain why in general, if this assumption is satisfied, it is preferable to carry out a t test rather than a Wilcoxon test. [4]
- 2 The manager of a gym is investigating a claim that, on the whole, women spend more time using the gym per visit than men. The manager selects independent random samples of 50 women and 50 men using the gym. He asks each person to record the time, in minutes, spent on this visit. The times for the 50 women are summarised by $\Sigma x = 3308$, $\Sigma x^2 = 222\,020$. For the 50 men, the sample mean is 62.68 and the sample variance is 134.0.
- (i) Calculate the sample mean and sample variance for the women. [3]
- (ii) Explain briefly why, even though the population variances are unknown, it is appropriate to use a test based on the Normal distribution to investigate the claim. [1]
- (iii) Carry out a test at the 10% significance level to investigate the claim. State your hypotheses and conclusions clearly. [11]
- 3 A random sample of 11 countries is selected. The adult literacy rate and the percentage of children under 16 who attend school in these countries are shown in the table.

Country	A	B	C	D	E	F	G	H	I	J	K
Adult literacy rate	41	56	90	97	83	95	98	29	59	76	68
Percentage attending school	67	70	78	91	84	94	92	47	75	90	83

- (i) Draw a scatter diagram to illustrate these data. [3]
- (ii) Comment on whether, in view of the scatter diagram, it is appropriate to carry out a hypothesis test based on the product moment correlation coefficient. [2]
- (iii) Calculate the value of Spearman’s rank correlation coefficient. [5]
- (iv) Using your answer to part (iii), test at the 1% level of significance whether it is reasonable to assume that adult literacy rate and percentage of children under 16 who attend school are positively associated. State your hypotheses and conclusions clearly. [5]

Section B (27 marks)

- 4** Researchers at a crop breeding institute are investigating how the yield of a particular variety of pea is affected by the application of either organic or non-organic fertiliser. They apply three different treatments to a number of plots of peas in a field.

Treatment A: no fertiliser.
 Treatment B: organic fertiliser.
 Treatment C: non-organic fertiliser.

- (i) At least one of the three treatments is a control and at least one is experimental. Identify the control and experimental treatments. [2]
- (ii) Explain why the researchers apply no fertiliser to one area. [1]
- (iii) Explain why it would not be sensible to divide the field into three strips and apply one treatment to each strip. [2]
- (iv) The field is in fact divided into 100 equal-sized plots. 10 of these plots are randomly assigned to each treatment. Explain how 30 plots can be selected at random from 100 plots. [3]

Two of the plots with Treatment A (no fertiliser) and three with Treatment B (organic fertiliser) were infected with a disease and the whole of the crop in each of these plots had to be destroyed. The yields, in kg per plot, from the remaining plots were as follows.

Treatment A	231	256	221	289	216	238	241	262
Treatment B	278	294	241	250	290	309	291	

For Treatment A the sample mean is 244.25 and the sample variance is 574.2.

For Treatment B the sample mean is 279 and the sample variance is 612.7.

- (v) It is thought that the average yield for the crop with organic fertiliser may be greater than that for the crop with no fertiliser. State the assumptions which are required for a t test to examine whether the mean yields of the crops with organic fertiliser and with no fertiliser appear to be the same. Given that these assumptions are valid, carry out the test at the 5% significance level, stating your hypotheses and conclusions clearly. [14]
- (vi) The researchers wish to test whether there is any difference in average yield between peas grown with organic fertiliser and those grown with non-organic fertiliser. They carry out a Wilcoxon rank sum test. State appropriate hypotheses for the test. Given that the value of the test statistic is 42 and the sample sizes for organic and non-organic are 7 and 8 respectively, complete the test at the 5% level, stating your conclusions clearly. [5]

Friday 1 June 2012 – Morning

AS GCE MEI STATISTICS

G243 Statistics 3 (Z3)

QUESTION PAPER

Candidates answer on the Printed Answer Book.

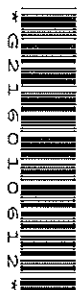
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Other materials required:

- Scientific or graphical calculator

Duration: 1 hour 30 minutes



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Section A (48 marks)

- 1 A delivery company has a fleet of 120 lorries. The company manager wishes to switch from conventional diesel fuel to a blend of biodiesel fuel. Before switching, he decides to check whether using biodiesel will affect the fuel consumption of the lorries. He selects 8 lorries and checks their fuel consumption using conventional diesel and then again using biodiesel.

(i) Describe how the manager could select this sample by systematic sampling. [3]

The results, measured in litres per 100 km, are as follows.

Lorry	A	B	C	D	E	F	G	H
Conventional diesel	39.2	34.4	28.6	25.0	27.8	31.9	33.6	38.7
Biodiesel	38.7	34.0	29.2	25.3	27.8	32.6	33.9	39.3

- (ii) Use a t test to examine, at the 5% significance level, whether it appears that the mean fuel consumption for lorries using biodiesel is the same as that for lorries using conventional diesel. [11]
- (iii) State the distributional assumption which is necessary for this test to be valid. Name an alternative test which could be performed if this assumption is not valid. [2]

- 2 A researcher is checking the breaking stress of titanium components from two different manufacturers. These components are costly and so the researcher can only test a small sample from each manufacturer. The researcher wishes to examine whether, on the whole, the breaking stresses of components from the two manufacturers can be considered to be the same. The breaking stresses of a random sample of 10 components from each manufacturer, measured in suitable units, are as follows.

Manufacturer A	70.6	75.2	77.9	75.4	79.3	77.6	77.0	73.1	73.0	73.5
Manufacturer B	76.9	74.6	72.6	73.7	74.2	70.4	70.1	78.5	75.0	72.7

- (i) Explain briefly whether it is appropriate to carry out a Wilcoxon signed rank test in this situation. [2]
- (ii) The researcher suspects that the populations are not Normally distributed. Carry out a suitable test at the 10% significance level. [10]
- (iii) Would the outcome of the test be different if you had ranked the data in reverse order? [1]
- (iv) Name an alternative test which would have been preferable if the researcher had been able to collect data on 100 components from each manufacturer. Discuss briefly whether the population variances would need to be known in order to carry out this test. [3]

- 3 An education authority collects data on attendance level, x , and academic performance, y , of children in its schools, both measured in suitable units. Summary statistics for 50 randomly selected children are shown below.

$$\Sigma x = 26.43 \quad \Sigma y = 265.4 \quad \Sigma x^2 = 16.62 \quad \Sigma y^2 = 1576.9 \quad \Sigma xy = 147.6 \quad n = 50$$

- (i) Calculate the product moment correlation coefficient. [5]
- (ii) Carry out a hypothesis test at the 5% significance level to determine whether there appears to be positive correlation between x and y . [6]
- (iii) What distributional assumption is required for this test? Explain how a scatter diagram may be used to check whether this assumption may be valid. [2]
- (iv) Subsequently it is decided to calculate the correlation coefficient for the whole population of students of the education authority and it is found to be 0.291. Explain briefly why it is not valid to perform a hypothesis test in this case. [1]
- (v) Because this correlation coefficient is positive, it is suggested that boosting attendance levels will enhance academic performance. Explain briefly why this may not be the case. [2]

[Question 4 is printed overleaf.]



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Section B (24 marks)

- 4 Scientists at a pharmaceutical company are developing a new drug to treat the common cold. They wish to find out whether patients get better more quickly if given this drug rather than being given other treatments. They compare the performance of the new drug with two other treatments which are already on the market, paracetamol and ibuprofen, and also with giving no drug.

They classify the treatments as follows.

Treatment A: new drug
 Treatment B: paracetamol
 Treatment C: ibuprofen
 Treatment D: no drug

- (i) Explain why the scientists include treatment D in the investigation. [2]
- (ii) In order to test whether the new drug is better than the other treatments, it is suggested that 4 people who have symptoms of the common cold are selected. The first person is given treatment A, the second is given treatment B, the third is given treatment C and the fourth is given treatment D. If the person who is given treatment A gets better more quickly than the others, then the new drug would be regarded as being better than the other treatments. Comment critically on this suggestion. [3]
- (iii) An alternative approach is suggested, in which a large number of volunteers are infected with the same strain of the common cold virus. Each is then given one of the four treatments. The speed of recovery under each treatment is noted. Briefly comment on this suggestion. [2]

In fact it is decided to test the treatments on all employees of the pharmaceutical company who are willing to take part in the trial. As soon as any of these employees has symptoms of the common cold, one of the four treatments is allocated to the employee. The time that the employee takes to recover is noted.

- (iv) Explain why the treatments should be allocated randomly. [2]
- (v) Explain why a sample of employees of the company would not be representative of the whole of the population of the UK. [2]
- (vi) In fact, the employees given treatment D are given 'placebo' tablets which appear identical to the tablets containing the new drug. These placebo tablets are designed to have no medical effect. Explain the purpose of using placebo tablets. [2]

The scientists wish to compare treatments A and D. The recovery times, in days, of 43 employees under treatment A and 49 employees under treatment D are available. The means and variances of these recovery times are shown below.

Treatment A:	mean 4.770	variance 1.747
Treatment D:	mean 4.926	variance 1.594

- (vii) Carry out a test at the 5% significance level to examine whether employees appear to have shorter recovery times under treatment A than under treatment D. [11]

Monday 10 June 2013 – Morning

AS GCE MEI STATISTICS

G243/01 Statistics 3 (Z3)

QUESTION PAPER

Candidates answer on the Printed Answer Book.

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Other materials required:

- Scientific or graphical calculator

Duration: 1 hour 30 minutes



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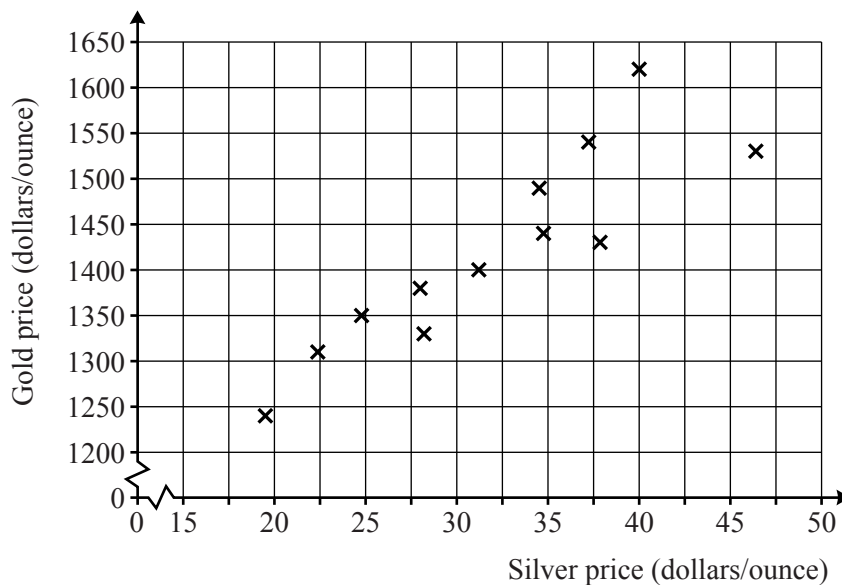
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Section A (45 marks)

- 1 (i) A test is to be carried out to examine the relationship between two variables. Explain briefly why, provided that the conditions for its use are satisfied, it is preferable to carry out a test based on the product moment correlation coefficient, rather than a test based on Spearman's rank correlation coefficient. [2]

A student is investigating the prices of gold and silver over a period of one year. He randomly chooses 12 days over the course of the year and records the prices of both metals, in dollars per ounce, on those days. The prices are given below, together with a scatter diagram to illustrate the data.

Silver price	19.5	22.3	28.2	24.7	28.0	31.2	37.9	34.7	34.5	46.3	37.2	40.0
Gold price	1240	1310	1330	1350	1380	1400	1430	1440	1490	1530	1540	1620



- (ii) State a condition which is required for the use of a test based on the product moment correlation coefficient. Explain why, in the light of the scatter diagram, it may not be appropriate to carry out such a test. [2]
- (iii) Calculate the value of Spearman's rank correlation coefficient. [5]
- (iv) Using your answer to part (iii) carry out a test, at the 5% level of significance, to determine whether it is reasonable to assume that prices of gold and silver are positively associated. [6]

- 2 A scientist from a company which manufactures baby milk is investigating whether babies fed with two different brands of baby milk from birth gain the same amount of weight, on average, in their first year of life. He randomly selects 100 babies who have been fed Brand A and another 100 babies who have been fed Brand B. The weight gains in kilograms have the following means and variances.

Brand A:	Sample mean 5.834	Sample variance 1.272
Brand B:	Sample mean 5.920	Sample variance 1.318

- (i) Explain why, even though the distributions of the underlying populations are unknown, a test based on the Normal distribution is appropriate. [2]
- (ii) Carry out a test, at the 5% level of significance, to examine whether there appears to be a difference in average weight gain between the two brands. [11]
- (iii) Suppose instead that samples each of only 10 babies had been selected, and that the distributions of the underlying populations were unknown. Name another test which could have been used. State the null hypothesis which would have been tested. [2]
- 3 A university psychologist is investigating whether the time taken to complete a sudoku puzzle is affected by consumption of a small quantity of alcohol. She believes that consumption of alcohol will increase the median time taken. She randomly chooses 12 students from her classes who regularly do sudoku puzzles. Each student is given a particular puzzle to do; the time, in minutes, taken to complete it is recorded. Each student is then given a single unit of alcohol and required to complete a second puzzle of similar standard; the time taken to complete it is again recorded. The times are as follows.

Student	A	B	C	D	E	F	G	H	I	J	K	L
Time – no alcohol	6.2	13.7	15.5	11.0	11.6	9.6	14.6	10.2	19.8	12.9	5.9	14.7
Time – with alcohol	7.1	13.3	13.8	13.2	13.0	11.2	13.4	13.9	18.0	16.4	4.8	16.0

- (i) Carry out a test, at the 5% level of significance, to examine whether the psychologist's belief concerning the median time taken appears to be correct. [11]
- (ii) Explain why the psychologist has used a paired design. [2]
- (iii) Explain briefly one improvement which could be made to the design of this experiment. [2]

Section B (27 marks)

4 (i) State two requirements for systematic sampling to be a sensible method for selecting a sample for a survey. [2]

(ii) Describe how to choose a systematic sample of 8 potato plants from a single row of 80 potato plants. [2]

A researcher is running a trial of two new varieties of potato, P and Q. A field contains 20 rows of each variety, with 80 plants in each row; the varieties are planted in alternate rows. The researcher intends to dig up 8 plants of each variety and measure the weight of potatoes produced by each plant. He considers the following methods of choosing a sample for each variety.

- A Choose plants near the field entrance to avoid disturbing the rest of the crop.
- B Systematically select 8 plants from one row of each variety in the field.
- C Number all of the plants and then randomly select 8 of each variety.

(iii) Discuss advantages and disadvantages of these methods. [6]

(iv) Name the types of sampling described in methods A and C. [2]

The researcher wishes to compare the weights in kilograms of potatoes in the two samples to test whether the population mean for variety P is equal to the population mean for variety Q. He selects a random sample of 8 potatoes of each variety.

(v) State the assumptions which are required for a t test to examine whether the means appear to be equal. Given that these assumptions are valid, use the data below to carry out the test at the 5% significance level.

Variety P:	Sample mean 1.824	Sample variance 0.124
Variety Q:	Sample mean 2.191	Sample variance 0.230

[15]

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Thursday 12 June 2014 – Afternoon

AS GCE MEI STATISTICS

G243/01 Statistics 3 (Z3)

QUESTION PAPER

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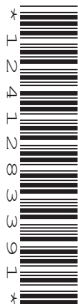
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Other materials required:

- Scientific or graphical calculator

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- The number of marks is given in brackets [] at the end of each question or part question on the Question Paper.
- You are advised that an answer may receive **no marks** unless you show sufficient detail of the working to indicate that a correct method is being used.
- The total number of marks for this paper is **72**.
- The Printed Answer Book consists of **12** pages. The Question Paper consists of **4** pages. Any blank pages are indicated.

INSTRUCTION TO EXAMS OFFICER/INVIGILATOR

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Section A (48 marks)

- 1 A hospital consultant is checking the waiting times for patients at hospital clinics. The waiting times, in minutes, for random samples of morning and afternoon appointments are as follows.

Morning	6	9	14	15	18	23	24	29	33	37	52	61
Afternoon	2	5	7	12	13	19	20	21	27	47		

The consultant suspects that the waiting times are shorter, on average, at afternoon appointments than at morning appointments.

- (i) Name two tests which could be used to analyse these data. Under what circumstances would you choose one test rather than the other? [4]
- (ii) Given that it is not known whether or not the populations are Normally distributed, carry out a test at the 5% significance level to investigate the consultant's suspicion. [10]
- (iii) Another consultant suggests that if there had been equal numbers of morning and afternoon appointments, a paired design could have been used. Comment briefly on this suggestion. [2]
- 2 An internet retailer employs workers to pick goods for packing at its warehouse. The management introduces an incentive bonus scheme in order to try to reduce the average time which it takes a picker to pick an item. The picking times in seconds for a random sample of 11 workers, before the introduction of the incentive scheme and one week after the introduction of the scheme, are as follows.

Worker	A	B	C	D	E	F	G	H	I	J	K
Before incentive	33.5	31.7	34.2	36.5	37.1	29.6	30.2	33.0	32.9	28.7	30.3
After incentive	32.6	30.3	33.7	36.8	36.9	30.1	29.6	32.0	31.6	29.2	29.4

A test is to be carried out to investigate whether it appears that the average picking time is reduced after the incentive scheme is introduced.

- (i) Briefly explain why it is better to carry out a paired sample test rather than a two-sample test for these data. [2]
- (ii) Name a paired sample test which can be used if the distribution of the population of differences is unknown. [1]
- (iii) State any distributional assumptions necessary for the use of a paired sample t test. [2]
- (iv) Use a t test to examine, at the 5% significance level, whether it appears that the average picking time is less after the incentive scheme is introduced. [11]

- 3 In order to investigate whether there is positive correlation between rainfall and crop yields, the total rainfall, x mm, and the weights per square metre, y kg, of a particular crop were recorded in a number of fields. These fields were chosen randomly from a large number of fields. The data are shown below.

x	36	50	44	72	44	74	64	50	39	30	61
y	2.2	5.0	6.2	8.4	1.8	7.4	4.3	2.2	7.5	3.6	7.6

- (i) Draw a scatter diagram to illustrate these data. [3]
- (ii) Calculate the value of the product moment correlation coefficient. [2]
- (iii) State an assumption about the underlying population which is required to carry out a test based on the product moment correlation coefficient. Explain why, in the light of the scatter diagram, it is reasonable to suppose that this assumption may be valid. [2]
- (iv) Carry out a hypothesis test at the 1% significance level to determine whether there appears to be positive correlation between x and y . [6]
- (v) Explain why it is important that the 11 fields were chosen randomly. [2]
- (vi) Name an alternative test which could have been carried out if the assumption in part (iii) was not valid. [1]

Question 4 begins on page 4.

Section B (24 marks)

4 A researcher is investigating whether the average lengths of fish of a particular species in two African lakes P and Q are equal. Each day fishermen catch large numbers of these fish from each lake. The researcher is able to measure the lengths of any of the fish which have been caught. For each lake, she considers a number of ways of selecting a sample of 50 fish of this species.

- A: Randomly select 50 fish which have been caught by a particular fisherman on a particular day.
 B: Choose 5 fishermen and randomly select 10 fish caught by each of them on a particular day.
 C: Choose 5 fishermen and randomly select 2 fish caught by each of them for a period of 5 days.

- (i) Which of these methods is likely to result in the most representative sample from the population of fish in the lake? Briefly explain your answer. [2]
 (ii) The researcher decides to use Method B. Given that a particular fisherman on one of the lakes catches 120 fish, explain how she can select a simple random sample of size 10 from these 120 fish. [3]
 (iii) Explain why she should sample the fish from the two lakes on the same day if possible. [2]

On a later occasion the researcher selects simple random samples of 50 fish from each lake. The lengths in mm of the 50 fish from Lake P are summarised by $\sum x = 7683.5$, $\sum x^2 = 1191300$. For the 50 fish from Lake Q, the sample mean is 151.7 mm and the sample standard deviation is 15.6 mm.

- (iv) Calculate the sample mean and sample standard deviation for the fish from Lake P. [3]

The researcher wishes to investigate whether there appears to be any difference in the average lengths of the fish from the two lakes.

- (v) Explain why it is appropriate to carry out a hypothesis test based on the Normal distribution. [1]
 (vi) Carry out the hypothesis test at the 10% significance level. [11]
 (vii) Explain why, even if the result of a hypothesis test is 'reject H_0 ', the null hypothesis may still be true. [2]

END OF QUESTION PAPER

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Tuesday 9 June 2015 – Morning

AS GCE MEI STATISTICS

G243/01 Statistics 3 (Z3)

QUESTION PAPER

Candidates answer on the Printed Answer Book.

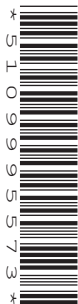
OCR supplied materials:

- Printed Answer Book G243/01
- MEI Examination Formulae and Tables (MF2)

Other materials required:

- Scientific or graphical calculator

Duration: 1 hour 30 minutes



INSTRUCTIONS TO CANDIDATES

These instructions are the same on the Printed Answer Book and the Question Paper.

- The Question Paper will be found inside the Printed Answer Book.
- Write your name, centre number and candidate number in the spaces provided on the Printed Answer Book. Please write clearly and in capital letters.
- **Write your answer to each question in the space provided in the Printed Answer Book.** Additional paper may be used if necessary but you must clearly show your candidate number, centre number and question number(s).
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Answer **all** the questions.
- Do **not** write in the bar codes.
- You are permitted to use a scientific or graphical calculator in this paper.
- Final answers should be given to a degree of accuracy appropriate to the context.

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Section A (46 marks)

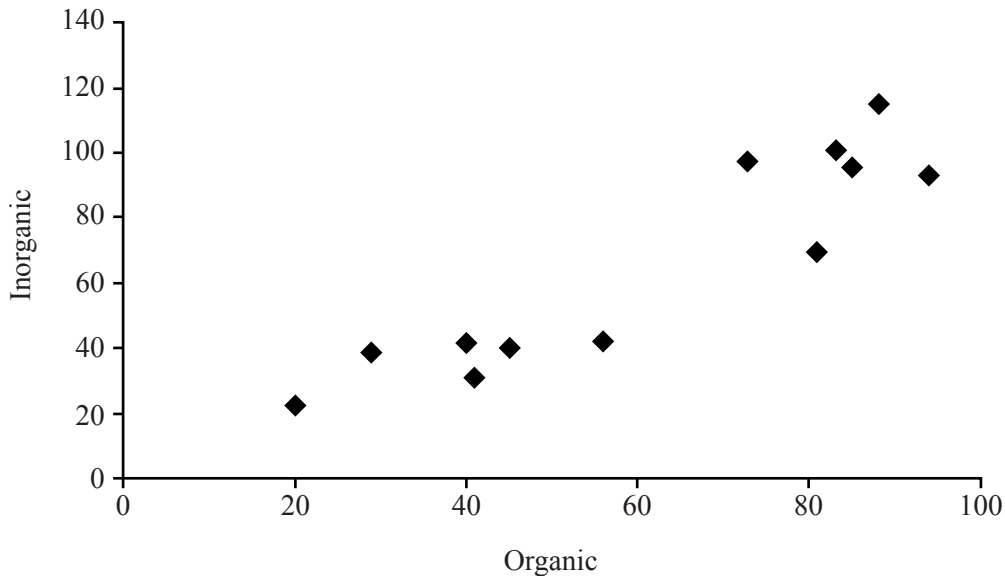
- 1 An airline consultant is investigating the punctuality of two airlines, A and B, which share the same route. She suspects that, on average, flights with airline A will arrive earlier than flights with airline B. She selects random samples of 50 flights for each airline. The difference in minutes between the scheduled arrival times and actual arrival times are denoted by x for airline A and y for airline B. A negative value indicates a late arrival. You are given that $\Sigma x = 275.8$, $\Sigma x^2 = 2910.5$ and the sample mean and sample standard deviation of y are 3.74 and 6.45 respectively.
- (i) Calculate the sample mean and sample standard deviation of x . [3]
- (ii) Carry out a test at the 10% significance level to investigate the consultant's suspicion. [11]
- (iii) Suppose that a 1% significance level is used instead of a 10% significance level in a hypothesis test such as this, and that the null hypothesis is true. Is the null hypothesis more likely, equally likely or less likely to be rejected? Briefly explain your answer. [2]
- 2 Two friends, Jenna and Ronin, are comparing the speeds of copying files from a USB drive to their computers. They wish to check if, on average, the copying speeds are different. 11 files are randomly selected and Jenna and Ronin each copy these files onto their computers. The copying speeds, in suitable units, are as follows.

File	A	B	C	D	E	F	G	H	I	J	K
Ronin	9.98	9.79	9.68	9.74	10.33	9.94	10.56	9.91	10.23	11.23	10.64
Jenna	10.20	11.36	8.68	10.50	10.97	7.86	8.84	9.26	10.46	11.41	10.73

- (i) Briefly explain why it is better to use the same files to copy onto both of the computers. [2]
- (ii) State the distributional assumption necessary for the use of a paired sample t test. [2]
- (iii) Use a paired sample t test to examine, at the 5% significance level, whether it appears that there is any difference between the average copying speeds for the two computers. [11]

- 3 An agricultural scientist thinks that there may be a relationship between levels of organic and inorganic phosphorus in the soil in a river basin. She takes samples of soil from 12 randomly chosen locations. The levels of both types of phosphorus in each of the samples, measured in suitable units, are given below. The data are also shown on a scatter diagram.

Location	1	2	3	4	5	6	7	8	9	10	11	12
Organic	85	83	73	20	29	88	94	45	41	81	56	40
Inorganic	95	100	97	22	39	115	93	40	31	69	42	41



- (i) Explain why, in view of the shape of the scatter diagram, the assumptions required to carry out a test based on the product moment correlation coefficient may not be satisfied. [3]
- (ii) Calculate the value of Spearman's rank correlation coefficient for these data. [5]
- (iii) Using your answer to part (ii) carry out a test, at the 1% level of significance, to determine whether it is reasonable to assume that levels of organic and inorganic phosphorus are positively associated. [7]

Question 4 begins on page 4.

Section B (26 marks)

- 4 A researcher is investigating the performances of various groups of people in an online typing test.
- (i) He first considers whether to use a census or a survey. Give one advantage of each approach. [2]
 - (ii) The researcher decides to use a survey to select 12 women who have taken the typing test. Explain why it would not be sensible to select the first 12 women who have taken the test on a particular day. [2]
 - (iii) He then considers selecting people by systematic sampling. Given that 960 women have taken the test, explain how he can select a systematic sample of 12 of them. [3]

The researcher wishes to investigate whether there is any difference between the average test results of women and men. He takes random samples of 12 women and 12 men. The results, measured in words per minute, rounded to the nearest integer, are as follows.

Women	18	21	26	27	29	33	36	37	41	46	65	78
Men	13	14	22	23	24	28	30	31	35	42	43	61

- (iv) State the assumptions which are required for a t test to examine whether there is any difference in the mean typing speeds of women and men. [2]
- (v) Draw a histogram for the data for women, using class intervals 9.5–19.5, 19.5–29.5, 29.5–39.5, 39.5–49.5, 49.5–79.5. Name the type of skewness shown by the histogram and explain why it would be unwise to assume an underlying Normal distribution. [5]
- (vi) Carry out an appropriate test, at the 5% significance level, to investigate whether it appears that the median performances of women and men are the same. [10]
- (vii) Explain why the researcher took a random sample of 12 women and 12 men, rather than randomly selecting just 1 woman and 1 man. [2]

END OF QUESTION PAPER

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