Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
6	
TOTAL	

General Certificate of Education
Advanced Level Examination
June 2010

Statistics SS06

Unit Statistics 6

Tuesday 22 June 2010 1.30 pm to 3.00 pm

For this paper you must have:
- the blue AQA booklet of formulae and statistical tables.

You may use a graphics calculator.

Time allowed
- 1 hour 30 minutes

Instructions
- Use black ink or black ball-point pen. Pencil should only be used for drawing.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- Write the question part reference (eg (a), (b)(i) etc) in the left-hand margin.
- You must answer the questions in the spaces provided. Do not write outside the box around each page.
- Show all necessary working; otherwise marks for method may be lost.
- Do all rough work in this book. Cross through any work that you do not want to be marked.
- The **final** answer to questions requiring the use of tables or calculators should normally be given to three significant figures.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 75.

Advice
- Unless stated otherwise, you may quote formulae, without proof, from the booklet.

Answer **all** questions in the spaces provided.

1 In a comparison of scanning speeds of three different models of scanner, X, Y and Z, three different types of document, D_1, D_2 and D_3, are used.

Three experimental designs are suggested.

Design 1

X	**Y**	**Z**
D_1	D_2	D_3
D_1	D_2	D_3
D_1	D_2	D_3

Design 2

X	**Y**	**Z**
D_2	D_1	D_3
D_1	D_3	D_2
D_2	D_1	D_3

Design 3

X	**Y**	**Z**
D_1	D_2	D_3
D_3	D_1	D_1
D_2	D_3	D_2

For example:

Design 1 indicates that three type D_2 documents are scanned by scanner model Y;
Design 2 indicates that one type D_1 document and two type D_2 documents are scanned by scanner model X.

The order in which document types occur in each column is **not** important.

(a) Write down the name of **Design 3**. *(1 mark)*

(b) State **one** advantage of **Design 3** over **Design 2**. *(1 mark)*

(c) State **one** disadvantage of **Design 1**. *(1 mark)*

(d) Name the technique that you would use to analyse the data obtained from using **Design 3**. *(1 mark)*

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2 A process produces stainless steel parts for use in valves for oil pipelines. When the process is satisfactory, the diameters of these parts are normally distributed with mean 300 mm and standard deviation 1.6 mm. The process is to be controlled by taking a sample of 5 parts at regular intervals and measuring their diameters.

(a) Calculate upper and lower warning (95%) and action (99.8%) control limits for a control chart for means. You are **not** required to draw this chart. *(4 marks)*

(b) Calculate upper and lower control limits for a control chart for ranges. You are **not** required to draw this chart. *(2 marks)*

(c) State, with a reason, what action, if any, you would recommend if the next sample of 5 parts had diameters of:

(i) 297.4, 296.0, 298.9, 297.2, 297.9;

(ii) 296.8, 299.1, 303.2, 303.6, 301.2. *(4 marks)*

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3 An investigation was carried out into which type of pepperoni pizza was most popular. Ten people, who may be regarded as a random sample, were each given a plate on which there were two pepperoni pizzas: one of Type A and one of Type B. Each pizza weighed 450 g. After 15 minutes, the amounts, in grams, of pizza eaten, for each type and for each person, were recorded.

It was assumed that each person would eat more of the type of pizza that he or she preferred.

The results are given in the table.

Person \ Pizza	Type A	Type B
1	88	0
2	290	239
3	0	0
4	48	8
5	382	79
6	298	405
7	39	15
8	163	132
9	329	14
10	264	152

(a) Carry out a paired *t*-test, using the 5% level of significance, to investigate for a mean difference between the amounts of pizza eaten.

Interpret your conclusion in context. *(9 marks)*

(b) State the distributional assumption that you have made in order to carry out the test in part **(a)**. *(1 mark)*

(c) Comment on the suggestion that it would be more appropriate to carry out a sign test on the given data to investigate for a difference between the amounts of pizza eaten. *(1 mark)*

(d) Apply a sign test, using the 5% level of significance, to the data given in the table to investigate for a difference between the average amounts of pizza eaten. *(5 marks)*

(e) Comment on your findings in parts **(a)** and **(d)** with reference to your answer to part **(c)**. *(2 marks)*

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4 A particular component, used in CNC (Computer Numerically Controlled) machines, fails to work if its temperature is too high.

The company operating the CNC machines orders a batch of such components and operates the following acceptance sampling plan:

> randomly select 10 components from a batch and accept the batch if the mean temperature at which the components fail to work exceeds 93 °C.

The temperatures at which the components fail to work can be assumed to be normally distributed with standard deviation 3.1°C.

(a) Find the probability that a batch will be accepted when the mean temperature at which the components fail to work is:

(i) 91°C;

(ii) 94 °C. *(4 marks)*

(b) The company decides to redesign the plan. It now requires that the probability of rejecting a batch, when the mean temperature at which the components fail to work is 94 °C, should be less than 10%.

The company also decides to reduce the sample size to 8.

The batch will be accepted if the sample mean temperature exceeds x °C. Find the largest possible value of x which will give a plan satisfying the company's requirements. *(4 marks)*

(c) Operating an acceptance sampling plan may be regarded as equivalent to carrying out a hypothesis test where the null hypothesis is that the batch is satisfactory.

Explain the meaning of a Type I error in the context of acceptance sampling. *(2 marks)*

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5 Two suggested acceptance sampling schemes are to be considered by a company that manufactures hinges for kitchen furniture.

Hinges are considered non-conforming if they do not open and close satisfactorily.

Scheme A Select a random sample of 50 hinges from a batch. Accept the batch if fewer than three hinges are non-conforming in the sample; otherwise reject the batch.

Scheme B Select a random sample of 30 hinges from a batch. Accept the batch if no hinges are non-conforming in the sample. Reject the batch if two or more hinges are non-conforming in the sample. If one non-conforming hinge is found in the sample, select a further random sample of 30 hinges from the batch. Accept the batch if a total of two or fewer non-conforming hinges are found in the 60 hinges sampled; otherwise reject the batch.

(a) Using **Scheme A**, find the probabilities of accepting batches containing 1%, 5%, 10% and 15% non-conforming hinges. *(2 marks)*

(b) Draw the operating characteristic for **Scheme A** on the graph opposite. *(2 marks)*

(c) Complete the table opposite by calculating the probability of accepting batches containing 10% non-conforming hinges when **Scheme B** is used. *(3 marks)*

(d) Draw the operating characteristic for **Scheme B** also on the graph opposite. *(1 mark)*

(e) (i) Give **one** reason for preferring Scheme A to Scheme B and give **one** reason for preferring Scheme B to Scheme A.

(ii) Suggest **two** other factors that the company should consider when deciding which sampling scheme to use. *(4 marks)*

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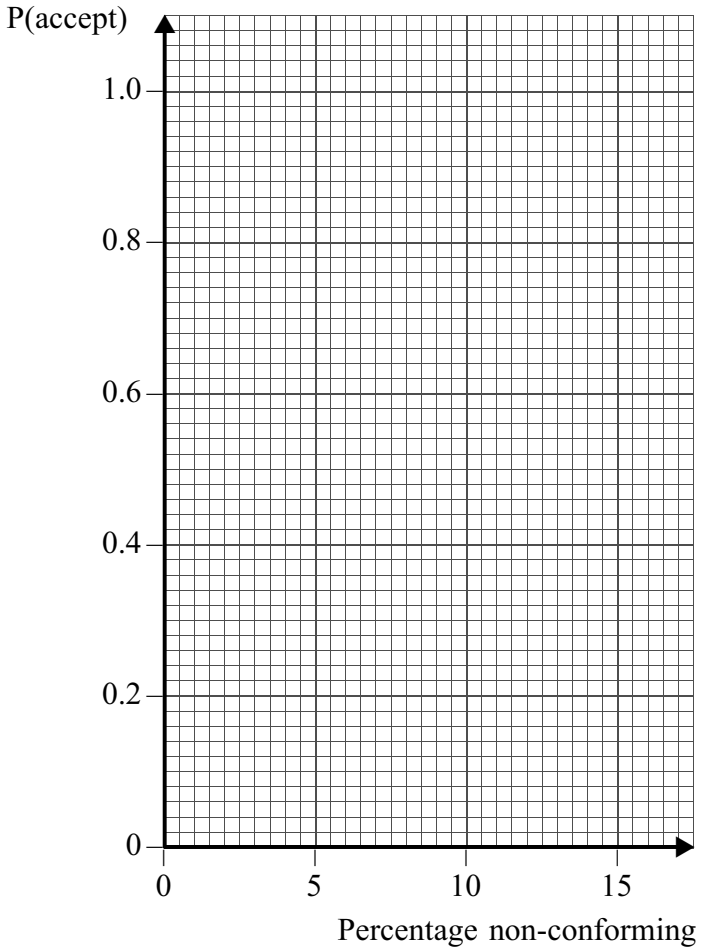
(b),(d)



(c)

Scheme B

p	1%	5%	10%	15%
P(accept)	0.956	0.402		0.010

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6 An environmental officer, Mikaela, was concerned about the effect of average wind speed on the level of atmospheric iron pollution in a town near a steel mill.

(a) She took measurements of iron levels on 23 days and wished to compare measurements for those days when the average wind speed was calm, windy or very windy.

The measurements are given in the following table.

Calm	1.27	0.97	1.25	0.74	1.17	0.89	0.68		
Windy	0.93	0.30	0.74	0.69	0.60	0.45	0.92	0.29	1.03
Very windy	0.25	0.43	0.30	1.01	0.65	0.87	0.50		

Investigate, at the 5% level of significance, for a difference between mean pollution levels for the three categories of average wind speed. Assume that the atmospheric iron pollution levels are normally distributed with a common variance. *(10 marks)*

(b) It was suggested to Mikaela that both humidity and air temperature might also affect the iron pollution level.

She subsequently produced a Latin square design using humidity levels of low, medium and high, and temperature levels T_1, T_2 and T_3.

Her design, together with her nine corresponding measurements, is shown.

		Humidity		
		Low	**Medium**	**High**
Wind speed	**Calm**	1.05 , T_1	1.14 , T_3	0.98 , T_2
	Windy	0.71 , T_3	0.82 , T_2	0.71 , T_1
	Very windy	0.51 , T_2	0.56 , T_1	0.68 , T_3

The partially completed ANOVA table which arises from the analysis of this Latin square is given below.

Source	**Sums of squares**	**Degrees of freedom**	**Mean square**	***F*-ratio**
Wind speed	0.34682	2	0.17341	
Humidity	0.01056			
Temperature				
Error				
Total	0.38302			

(i) Complete the ANOVA table above. *(6 marks)*

(ii) Hence carry out an analysis of variance to test, at the 5% level of significance, for a difference between mean iron pollution levels for the three categories of average wind speed. *(3 marks)*

(iii) Indicate, with reasons, whether the use of humidity and temperature as blocking factors has proved effective. *(2 marks)*

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END OF QUESTIONS