Surname		Other Names	
Centre Number		Candidate Number	
Candidate Signature			

For Examiner's Use

General Certificate of Education
June 2007
Advanced Level Examination

ENVIRONMENTAL SCIENCE **ESC7**
Unit 7 Alternative to Practical Investigation

Thursday 28 June 2007 9.00 am to 11.00 am

You will need no other materials.
You may use a calculator.

Time allowed: 2 hours

For Examiner's Use			
Question	Mark	Question	Mark
1		3	
2		4	
Total (Column 1) →			
Total (Column 2) →			
TOTAL			
Examiner's Initials			

Instructions

- Use blue or black ink or ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- Answer the questions in the spaces provided.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information

- The maximum mark for this paper is 75.
- The marks for questions are shown in brackets.
- You are reminded of the need for good English, clear presentation and appropriate use of specialist vocabulary. Question 4 should be answered in continuous prose. Quality of Written Communication will be assessed in this answer.
- This unit assesses your understanding of the relationship between the different aspects of Environmental Science.

Investigation to compare the effect of native and non-native tree species on woodlands in Britain

Aims of the Investigation

- To investigate the effect of planting non-native conifers on light levels and soil characteristics in woodlands
- To investigate the relationship between the date of establishment of native trees in Britain and the number of insect species they support
- To investigate the effect of modern forestry on populations of woodland birds
- To assess how the data can be used in the creation and management of woodlands for the conservation of native animal and plant species.

Common names are used throughout except in experimental data.

Background Information

Native tree species

Only about thirty species of broadleaved trees, three conifers (Scots pine, yew and juniper) and a few shrubs are classified as native trees. These began to colonise Britain after the end of the last Ice Age, about 11 000 years ago, when Britain was still part of mainland Europe. Plant species moved here as the climate warmed and the ice retreated northwards. The first colonisers were birch, aspen and willows followed by Scots pine and hazel. The next wave included oak and alder, followed by lime and elm, then ash, holly and beech. The evidence for this comes from the analysis of pollen grains found in peat deposits. The trees that became established varied in type according to soil, climate and altitude. With the gradual warming of the Earth's surface, the ice began to melt, raising the sea level until, about 8000 years ago, the English Channel flooded. This stopped the natural migration of plant species from the rest of Europe. This date is taken as the 'cut-off' point when deciding whether a plant species is native or not. The prehistoric forest was called 'wildwood', that is forest totally unaffected by civilisation. Some native trees, such as oak and beech, are important for timber, but many others are important for the beauty they provide and the wildlife they support.

Naturalised tree species

Naturalised species are deliberate or accidental introductions which have arrived in Britain within the past 8000 years. It was probably the Romans who first began importing exotic trees such as walnuts and sweet chestnuts, mainly for their edible seeds. This continued in the Middle Ages with the introduction of fruit and timber trees such as the sycamore. Many of these trees have been around for so long that they are mistakenly assumed to be native. Throughout the seventeenth and eighteenth centuries, plant hunters brought back many tree species from faraway places.

Recent introductions of exotic species

Many introduced trees have been planted on a trial basis to see if they might prosper in our temperate climate and provide timber. The most successful timber species are conifers, such as Sitka spruce, introduced in recent times, as they grow well and quickly on the poor upland soils which have little potential for growing agricultural crops.

The History of British Woodlands

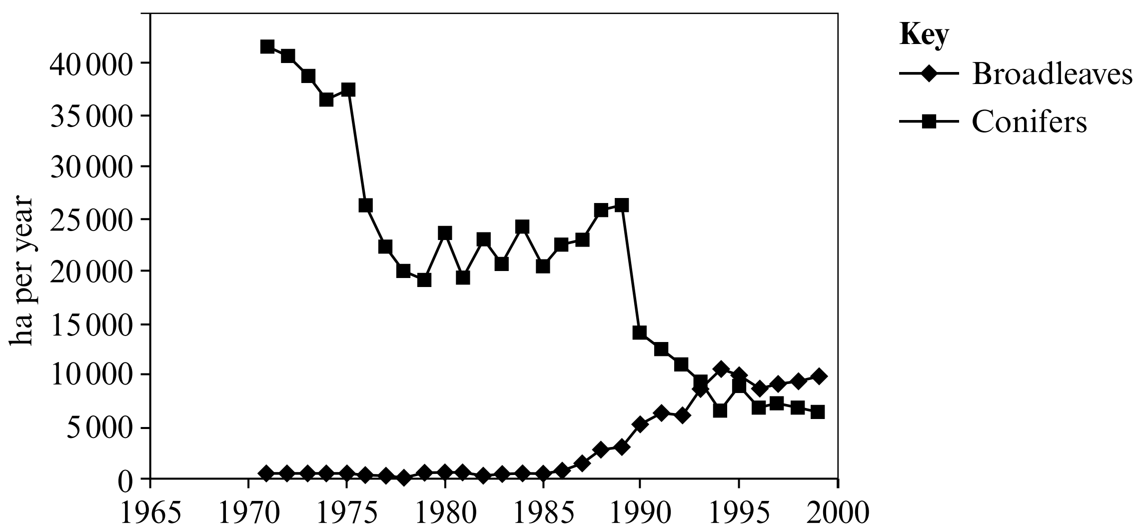
The removal of the 'wildwood' began when the Stone Age people cleared areas around their shelters for timber and fuel and to encourage the growth of grassland that would attract edible wild animals. Subsequently, large-scale clearance was carried out by the Romans to build their new road network, by the Tudors onwards for shipbuilding and, as urban populations grew, for building construction. In earlier times, woodlands were managed sustainably, eg by coppicing, but, by the middle of the nineteenth century, most of Britain's primary forest had been felled. After the First World War, only scattered remnants existed as hedges and isolated, often neglected, woodlands.

The poor state of Britain's woods was a cause for concern for the Government, so, in 1919, it set up the Forestry Commission, charged with restoring Britain's forests so that the UK could be less reliant on imported timber for mine pit props, paper pulp, building and furniture. The Forestry Commission bought huge areas of poor quality land, particularly in the hilly areas of Wales, Scotland and the Lake District. It planted coniferous trees, mainly non-native species, on a large scale so that the demand for timber could be met quickly. Non-native conifers were grown like an agricultural crop in plantations. They have had an effect on the wildlife of Britain because dense coniferous woodland was not found in the country naturally. Conifer plantations are dark and have few plants on the woodland floor. Coniferous trees cast deep shade and their needles take many years to rot, producing very acid compost. Although some birds thrive in conifer plantations, most birds and other animals cannot live there.

Modern Forestry in the UK

Today, the Forestry Commission mainly plants conifers for timber in smaller blocks and intersperses the blocks with native broadleaved trees. This is because the conifers mature quickly, and, when they are felled, the oaks and beeches will be left to form open woodland, similar to the original woodland of Britain. This system is much better for wildlife too. The Commission has also changed its policy of planting conifers across the skyline in upland areas and now tries to plant native broadleaved trees there to enhance the local landscape.

The graph shows the rates of broadleaf and conifer planting in Britain, 1971–1999.



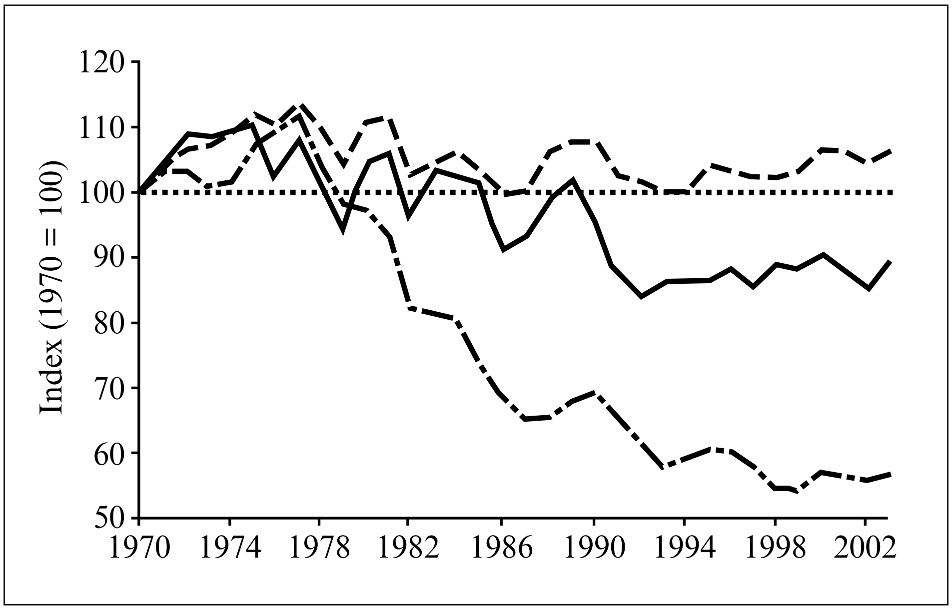
Problems of Invasive Non-native Plant Species

Plants such as the rhododendron, an evergreen prized for its flowers and introduced in the mid-eighteenth century from Mediterranean areas, are invasive and now widespread. Its dense growth prevents natural forest regeneration and can reduce species diversity as it shades out ground flora, tolerates deep shade and competes with native plants.

Decline in Woodland Bird Populations

There has been much recent publicity about the decline in the numbers of farmland birds. However, there is also serious concern that the populations of woodland bird species are declining as well. A census carried out by the British Trust for Ornithology suggests that there has been an 11 % decline in woodland birds since 1970, with a 30 % decline in the breeding populations of twelve of the less common species. Wild bird populations are considered to be a good indicator of the state of the countryside and its wildlife.

Populations of wild birds: 1970 to 2003



Key
All species
Woodland species
Farmland species
1970 baseline

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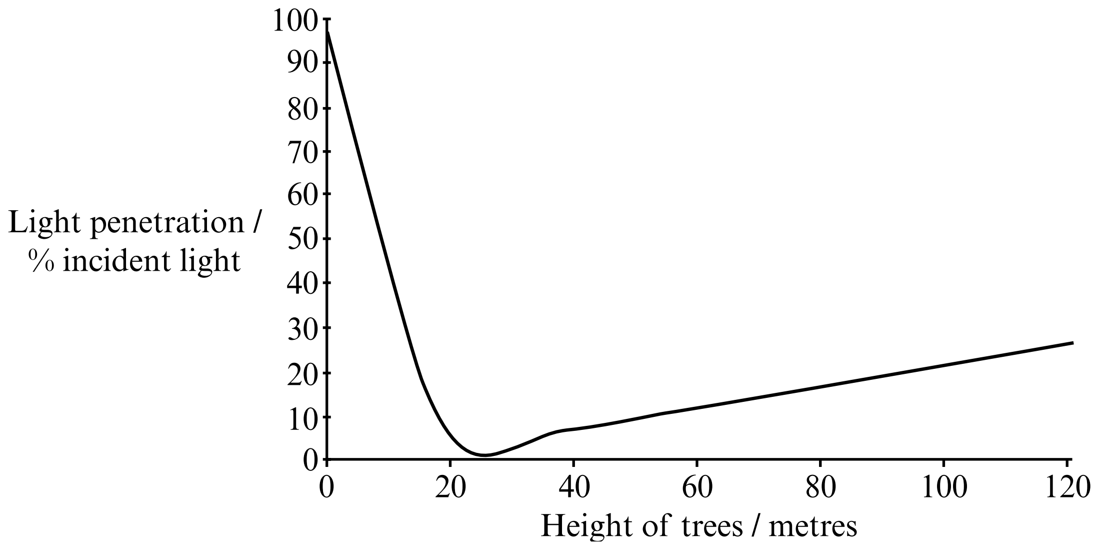
The following questions test the skills of planning, implementing, analysing and drawing conclusions from investigative work. They also test the ability to discuss the findings and evaluate methods, as well as suggesting modifications to the methods used and relevant further work.

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

1 The effect of planting non-native conifers on abiotic and soil characteristics in woodlands.

(a) The graph shows the amount of light reaching the forest floor as trees increase in height.



(i) Giving full practical details, describe **one** method for measuring light levels in woodlands. Justify your choice of method.

Method ....

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Justification ....

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(5 marks)

(ii) Describe **two** limitations of your chosen method.

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(2 marks)

(b) The effect of a conifer plantation on soil moisture content was investigated. The soil in a conifer plantation was compared with that in a nearby area of oak woodland.

(i) Six soil samples were taken from each area. Describe in detail a method for choosing the sampling sites and obtaining the soil samples.

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(5 marks)

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(ii) The soil moisture content of each sample was measured in the laboratory. Describe a method for measuring soil moisture content.

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(3 marks)

(c) The results from all six samples were recorded and the mean, median and standard deviation were then calculated. The results are shown in **Table 1**.

Table 1

	Percentage of soil moisture								
Soil sample number	**1**	**2**	**3**	**4**	**5**	**6**	**Mean**	**Median**	**Standard deviation**
Conifer plantation	9.8	10.7	12.3	11.9	12.0	10.2	11.15	11.3	1.05
Oak woodland	14.2	12.6	13.2	13.6	10.9	14.4	13.15	13.4	1.28

(i) What is the purpose of calculating both the mean and the median?

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(2 marks)

(ii) What additional information is provided by the standard deviation?

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(1 mark)

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(d) (i) State **three** other soil characteristics that might change as a result of planting conifers.

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(3 marks)

(ii) Describe a method for measuring **one** of these characteristics.

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(3 marks)

24

Turn over for the next question

2 Investigation into the number of insect species found on native and introduced tree species related to their order of colonisation or introduction into Britain.

Table 2 shows the approximate time of colonisation or introduction of twelve broadleaved tree species and the number of insect species found associated with them.

Table 2

Tree species Common name	Latin name		Number of Insect Species
Native species (in approximate order of arrival)			
Silver birch	*Betula pendula*		229
Hazel	*Corylus avellana*		102
Alder	*Alnus glutinosa*		90
Oak	*Quercus robur*		284
Wych elm	*Ulmus glabra*		82
Holly	*Ilex aquifolium*		10
Beech	*Fagus sylvatica*		64
Introduced species		**Approximate date of introduction / AD**	
Sweet chestnut	*Castanea sativa*	150	10
Walnut	*Juglans regia*	150	5
Sycamore	*Acer pseudoplatanus*	1300	15
Horse chestnut	*Aesculus hippocastanum*	1650	7
Rhododendron	*Rhododendron ponticum*	1765	31

(a) Suggest how data for the number of insect species associated with each tree may have been collected.

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(5 marks)

(b) The data suggest that there may be a link between the number of insect species associated with native and introduced trees and the time of the tree species' arrival in Britain.

(i) On the basis of the data in **Table 2**, it was decided to carry out a statistical test to see whether a significant relationship exists.

Formulate a hypothesis to use for the statistical test.

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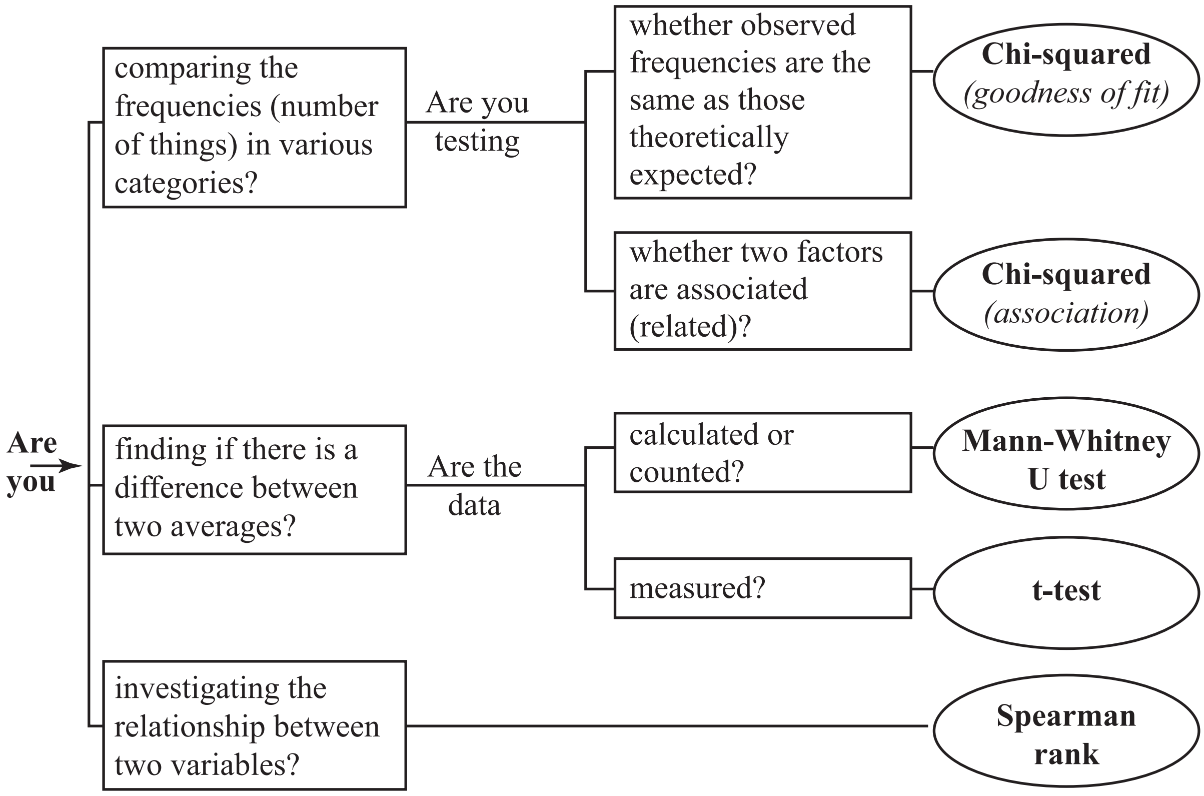
(1 mark)

Question 2 continues on the next page

(ii) Use the flow chart to select the appropriate statistical test. Give **two** reasons for your choice.



Choice of statistical test

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Reasons for choice

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(3 marks)

(iii) Carry out your chosen test using the data in **Table 2**. Show your working.

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(6 marks)

(iv) State your conclusion.

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(2 marks)

(c) Discuss the trends and anomalies shown by the data in **Table 2**.

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(4 marks)

(d) Excluding the measurement of abiotic factors, suggest how other data could be collected to investigate the effect of native and introduced species on animal populations in woodlands.

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(6 marks)

27

Turn over for the next question

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3 Investigation into population sizes of woodland birds

Wardens and members of a local bird-watching group carried out a survey of woodland birds over a six-year period at a nature reserve in South East England. They recorded all birds seen in the woodland areas over a five-month period from April to August each year. Recordings were taken on four, five or six days per month.

(a) Suggest limitations of the method used to collect the data that might affect the reliability of the results.

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(4 marks)

(b) The results from some of the bird species identified in the study are shown in **Table 3**. The figures indicate the total number of birds seen during the five-month recording period.

Table 3

Bird species Common name	Latin name	Year					
		2000	**2001**	**2002**	**2003**	**2004**	**2005**
Green woodpecker	*Picus viridis*	21	22	21	23	25	26
Great spotted woodpecker	*Dendrocopos major*	40	39	42	44	47	49
Lesser spotted woodpecker	*Dendrocopos minor*	13	12	12	10	8	7
Nightingale	*Luscinia megarhynchos*	20	19	21	20	17	21
Song thrush	*Turdus philomelos*	26	24	23	21	20	20
Mistle thrush	*Turdus viscivorus*	26	27	25	27	26	27
Blackcap	*Sylvia atricapilla*	42	44	43	47	49	51
Dunnock	*Prunella modularis*	58	59	57	59	62	61
Willow warbler	*Phylloscopus trochilus*	59	62	57	63	59	62
Nuthatch	*Sitta europaea*	27	31	32	30	34	35

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(i) On the graph paper, plot a graph to show the trends in the population sizes of the Green woodpecker, the Great spotted woodpecker and the Lesser spotted woodpecker.

(4 marks)

(ii) Summarise the trends shown by the results in **Table 3** and your graph.

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(4 marks)

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(c) Suggest **two** factors which the nature reserve wardens could investigate that might help to explain the population decline in some bird species.

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(2 marks)

14

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4 Conservation of woodlands

Suggest how the results of this investigation could be used for the creation and management of woodlands for the conservation of native animal and plant species.

Quality of Written Communication will be assessed in this answer.

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(10 marks)

10

END OF QUESTIONS

APPENDIX

Statistical formulae and tables

1 Mean

$$\bar{x} = \frac{\Sigma x}{n}$$

where:
$\bar{x}$ = mean
x = the individual measurements
n = total number of measurements
Σ = the sum of

2 Standard deviation(s)

$$s = \sqrt{\frac{\Sigma(x - \bar{x})^2}{n - 1}}$$

3 Chi-squared (χ^2) test

$$\chi^2 = \Sigma \frac{(O - E)^2}{E}$$

where:
Σ = the sum of
O = the observed value
E = the expected value

Critical values for the Chi-squared (χ^2) Test

Degrees of freedom (df)	**Level of significance (*p*)**				
	0.05	0.025	0.01	0.005	0.001
1	3.84	5.02	6.63	7.88	10.83
2	5.99	7.38	9.21	10.60	13.81
3	7.81	9.35	11.34	12.84	16.27
4	9.49	11.14	13.28	14.86	18.47
5	11.07	12.83	15.09	16.75	20.52
6	12.59	14.45	16.81	18.55	22.46
7	14.07	16.01	18.48	20.28	24.32
8	15.51	17.53	20.09	21.96	26.13
9	16.92	19.02	21.67	23.59	27.88
10	18.31	20.48	23.21	25.19	29.59
11	19.68	21.92	24.73	26.76	31.26
12	21.03	23.34	26.22	28.30	32.91
13	22.36	24.74	27.69	29.82	34.53
14	23.68	26.12	29.14	31.32	36.12

4 Mann-Whitney U Test

$$U = n_1 n_2 + \frac{n_1(n_1+1)}{2} - R_1$$

$$U' = n_1 n_2 + \frac{n_2(n_2+1)}{2} - R_2$$

where:
R_1 = sum of the ranks of sample 1
R_2 = sum of the ranks of sample 2
n_1 = size of the smaller sample
n_2 = size of the larger sample

Critical values for the Mann-Whitney U test (at the p = 0.05 level). If the smallest U value is less than or equal to the critical value then there is a significant difference between the two sets of data.

Values of n_1 \ Values of n_2	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1																				
2								0	0	0	0	1	1	1	1	1	2	2	2	2
3					0	1	1	2	2	3	3	4	4	5	5	6	6	7	7	8
4				0	1	2	3	4	4	5	6	7	8	9	10	11	11	12	13	13
5			0	1	2	3	5	6	7	8	9	11	12	13	14	15	17	18	19	20
6			1	2	3	5	6	8	10	11	13	14	16	17	19	21	22	24	25	27
7			1	3	5	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34
8		0	2	4	6	8	10	13	15	17	19	22	24	26	29	31	34	36	38	41
9		0	2	4	7	10	12	15	17	20	23	26	28	31	34	37	39	42	45	48
10		0	3	5	8	11	14	17	20	23	26	29	33	36	39	42	45	48	52	55
11		0	3	6	9	13	16	19	23	26	30	33	37	40	44	47	51	55	58	62
12		1	4	7	11	14	18	22	26	29	33	37	41	45	49	53	57	61	65	69
13		1	4	8	12	16	20	24	28	33	37	41	45	50	54	59	63	67	72	76
14		1	5	9	13	17	22	26	31	36	40	45	50	55	59	64	67	74	78	83
15		1	5	10	14	19	24	29	34	39	44	49	54	59	64	70	75	80	85	90
16		1	6	11	15	21	26	31	37	42	47	53	59	64	70	75	81	86	92	98
17		2	6	11	17	22	28	34	39	45	51	57	63	67	75	81	87	93	99	105
18		2	7	12	18	24	30	36	42	48	55	61	67	74	80	86	93	99	106	112
19		2	7	13	19	25	32	38	45	52	58	65	72	78	85	92	99	106	113	119
20		2	8	13	20	27	34	41	48	55	62	69	76	83	90	98	105	112	119	127

5 t-test

$$t = \frac{[\bar{x}_1 - \bar{x}_2]}{\sqrt{\left(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}\right)}} \qquad v = n_1 + n_2 - 2$$

where:
s = standard deviation (candidates should note that on some calculators the symbol σ may appear in place of the symbol s)
$\bar{x}$ = mean
n = sample size
v = degrees of freedom

Degrees of freedom (df)	***p* values**			
	0.10	0.05	0.01	0.001
1	6.31	12.71	63.66	636.60
2	2.92	4.30	9.92	31.60
3	2.35	3.18	5.84	12.92
4	2.13	2.78	4.60	8.61
5	2.02	2.57	4.03	6.37
6	1.94	2.45	3.71	5.96
7	1.89	2.36	3.50	5.41
8	1.86	2.31	3.36	5.04
9	1.83	2.26	3.25	4.78
10	1.81	2.23	3.17	4.59
12	1.78	2.18	3.05	4.32
14	1.76	2.15	2.98	4.14
16	1.75	2.12	2.92	4.02
18	1.73	2.10	2.88	3.92
20	1.72	2.09	2.85	3.85
22	1.72	2.08	2.82	3.79
24	1.71	2.06	2.80	3.74
26	1.71	2.06	2.78	3.71
28	1.70	2.05	2.76	3.67
30	1.70	2.04	2.75	3.65
40	1.68	2.02	2.70	3.55
60	1.67	2.00	2.66	3.46
120	1.66	1.98	2.62	3.37
∞	1.64	1.96	2.58	3.29

6 Spearman Rank Correlation Coefficient (r_s)

$$r_s = 1 - \frac{6 \sum d^2}{n(n^2 - 1)}$$

where:
$\sum$ = the sum of
d = the difference between each pair of ranks
n = sample size

Critical values for the Spearman Rank Correlation (r_s)

Number of pairs of measurements	Critical value
5	1.00
6	0.89
7	0.79
8	0.74
9	0.68
10	0.65
12	0.59
14	0.54
16	0.51
18	0.48
20	0.45
22	0.43
24	0.41
26	0.39
28	0.38
30	0.36

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