475.101/102/107/108
STATISTICS

Assignment 5, Semester 2, 2000
Due: 4pm Thursday, 12th October

Note:

- Assignment 5 will be marked out of 60 marks, 56 marks for questions 1 - 6 as shown below and 4 marks for communication, style and presentation. Please refer to Section B, Questions 17 to 19, in your purple covered *Course Resource Manual* for examples of how to set out your assignment answers. Your final mark will be converted to a mark out of 10 which will be recorded towards your course work.

Question 1. [9 marks]

(a) For each of the following descriptions of studies, state whether:
- they are experiments or observational studies.
- they are paired designs or produce two independent samples.

(i) A sample of 20 first semester data analysis students and a second sample of 20 second semester data analysis students are taken. The students' grade point averages are compared between first and second semester.

(ii) A chemical additive is designed to decrease the drying time for paint. 10 different types of paint are sampled. Each of the 10 samples is divided into two halves, one half of which is randomly chosen to have the additive mixed into it, the other half is left unchanged. 10 boards are spray painted with the different paints without the additive and 10 boards are spray painted with the different paints with the additive. The drying times of the paint are recorded.

(iii) 32 soft-drink bottles were filled by a machine. Half of these were randomly allocated to be filled by the machine with a dial setting of 25 psi operating pressure and the other half were filled by the machine when the operating pressure was set at 30 psi. The average volume was compared between the two settings.

(b) The signs of 12 differences that were calculated for a Sign test are:

\+ + 0 – + – + 0 + + + +

Calculate the *P-value* for testing the hypotheses: H_0: $\tilde{\mu}_{\text{Diff}} = 0$ vs H_1: $\tilde{\mu}_{\text{Diff}} \neq 0$.

(c) An experiment conducted on 4 groups (with sample sizes 14, 11, 8 and 13) resulted in the following ANOVA table:

Analysis of Variance for Time

Source	DF	SS	MS	F	P
Group	$\mathbf{df_1}$	575.46	191.82	$\mathbf{f_0}$	0.068
Error	$\mathbf{df_2}$	3144.94	74.88		
Total	$\mathbf{df_{tot}}$	3720.40			

What are the values of df_1, df_2, df_{tot} and f_0?

NOTES: If you are asked to carry out a significance test, you will need to:

1. state the parameter of interest in words.
2. state the null and alternative hypotheses and interpret the results.
3. when instructed to use either *Excel* or MINITAB:
   - make sure you are prepared for both questions 2 and 3 before you begin to use the computer.
   - **include** a copy of the computer output in your answers.
   - when using the computer report *P-values* to 3 decimal places.
4. when instructed to carry out a *t*-test using *Excel* **assume unequal variances**.

Question 2. [8 marks]

An insurance assessor from an Auckland insurance company is concerned about the high estimates the company has recently been receiving from a particular panel beater (Panel Beater 1) compared to those estimates received from another panel beater (Panel Beater 2). To investigate, 17 cars, each of which had recently been involved in an accident, were randomly selected and taken to both panel beaters for separate estimates of repair costs. The estimates (in dollars) from the panel beaters were:

Car	1	2	3	4	5	6	7	8	9
Panel Beater1	760	1020	950	130	300	630	530	620	220
Panel Beater2	730	910	840	150	270	580	490	530	200

Car	10	11	12	13	14	15	16	17
Panel Beater1	480	1130	1210	690	760	840	685	320
Panel Beater2	420	1100	1100	610	670	750	623	293

In this question you will investigate whether there is there a significant difference, on average, in repair estimates between Panel Beater 1 and Panel Beater 2.

(a) Use MINITAB to draw an appropriate plot of these data. (You should consider the design of this study to ensure the relevant plot is drawn.) Comment on any interesting features in the plots.

(b) Use MINITAB to investigate whether there is a significant difference, on average, in repair estimates between Panel Beater 1 and Panel Beater 2. Interpret your results.

(c) Use MINITAB to test the assumption that the underlying distribution of the differences in repair estimates between Panel Beater 1 and Panel Beater 2 is Normal. State the hypotheses being tested. Interpret the plot and the relevant test. **Note: to carry out the test in MINITAB choose the Ryan-Joiner option under the Normality Test in Basic Statistics**.

(d) Discuss the validity of the test performed in (b). You should use your answers in (a) and (c).

Question 3. [13 marks]

Birds being hit by aircraft is regarded to be a safety hazard to aircraft. A study investigating factors that may influence the frequency of birds being hit by aircraft was conducted at an international airport. As part of the study the noise levels of 22 randomly selected wide-bodied jets and 13 randomly selected narrow-bodied jets were measured immediately after their wheels left the ground. The data below gives the noise levels (in decibels) for the two types of jets taking part in the study.

```
Wide:   106.5  107.9   99.7  103.9  108.6  102.2  107.2  110.4  112.5  103.7
         98.4  105.6  101.6  104.8  107.7  103.2  107.1  107.8  108.0  108.8
        108.4  108.5

Narrow: 112.4  113.9  113.0  113.1  114.9  113.5  114.9  113.1  113.0  117.0
        111.5  113.9  114.8
```

(a) **(i)** Draw appropriate plot(s) for this data set preferably using a computer.
(ii) Compare the data sets in terms of centre and spread.
(iii) Do the sets of data look skewed? Briefly justify. Do the sets of data look badly skewed?

(b) **(i)** Is there a significant difference in the underlying mean noise levels of the two types of jet? Use *Excel* to investigate this question. Note: a 95% confidence interval for this difference, $\mu_{Wide} - \mu_{Narrow}$, is [-9.46, -6.04].

(ii) Below is the MINITAB output for the Mann-Whitney test investigating if there is a significant difference in the average noise levels of the two types of jet. State the hypotheses being tested and interpret the output.

MANN-WHITNEY TEST JET NOISE LEVELS

```
Mann-Whitney Confidence Interval and Test

Wide       N =  22     Median =      107.15
Narrow     N =  13     Median =      113.50
Point estimate for ETA1-ETA2 is       -7.00
95.0 Percent CI for ETA1-ETA2 is (-9.40,-5.40)
W = 255.0
Test of ETA1 = ETA2  vs  ETA1 not = ETA2 is significant at 0.0000
The test is significant at 0.0000 (adjusted for ties)
```

(c) Which of the two tests from **(b)** is most appropriate for this data? Justify your answer.

Question 4. [14 marks]

The durability of heavy machinery bearings was evaluated for four experimental lubricant types (labelled L1, L2, L3 and L4). Twelve bearings were randomly selected and assigned to each lubricant type. After being run through a series of tests, a wear and tear score was assessed for each bearing.

A copy of computer output for analysing the wear and tear score by type of lubricant is included on the following page.

(a) Briefly comment on what the dotplots of the data show.

(b) Would the outcome of the test on one bearing have any effect on outcome of the test of another bearing? What assumption for the *F*-test relates to this issue?

(c) Calculate the ratio of the sample standard deviation from the most variable group to the sample standard deviation from the least variable group.

(d) Briefly comment on the validity of the *F*-test.

(e) Name the non-parametric test equivalent to the *F*-test.

(f) Assume that an *F*-test is an appropriate test to use here.
- **(i)** State the null hypothesis for the test both in words and using symbols.
- **(ii)** State the alternative hypothesis for the test in words.
- **(iii)** What does the result of your *F*-test tell you about the mean wear and tear score of the four lubricants? Explain your answer in 1-2 sentences using plain English.

(g) Assuming the Tukey's pairwise comparisons are valid:
- **(i)** Are we able to determine which single lubricant has the lowest underlying mean wear and tear score? If so, name the lubricant.
- **(ii)** Are we able to determine which single lubricant has the highest underlying mean wear and tear score? If so, name the lubricant.
- **(iii)** Use an interval to estimate the underlying difference in mean wear and tear score between lubricant 2 and lubricant 3.
- **(iv)** Between which pairs of lubricants were there significant differences in the mean wear and tear scores at the 5% level?

Question 5. [6 marks]

For each of the situations below write a brief report in which you:

- Describe an experiment you could use to investigate the problem posed. Include details of how you would allocate treatments to subjects. Justify your choice of experimental design.
- Describe the hypotheses you would test.

(a) An agricultural scientist is interested in investigating effects, if any, of two different daily dosages of antibiotic on the weight gain of pigs. The scientist suggests daily dosages of 5mg and 10mg. There are 60 pigs available for experimentation and it is likely that the effectiveness of the antibiotic will depend on the starting weight of the pig. The weight gain of each pig over a two-month period is the measurement to be recorded.

(b) A hygiene researcher is interested in investigating whether health-care workers who wear rings are more susceptible to spreading bacteria than those who do not wear rings. There are 32 subjects available for experimentation. The measurement to be recorded is the bacteria count made on each subject's hands after careful washing. This measurement occurs after completion of a normal working day. There is likely to be considerable variation in each subject's care taken with washing his/her hands.

Question 6. [6 marks]

Turn to the page before the start of Chapter 10 / 1 in your green covered *Lecture Workbook*. Read the article "The politics behind opinion polls", *Sunday Star Times, 14 March 1999* and answer the following questions.

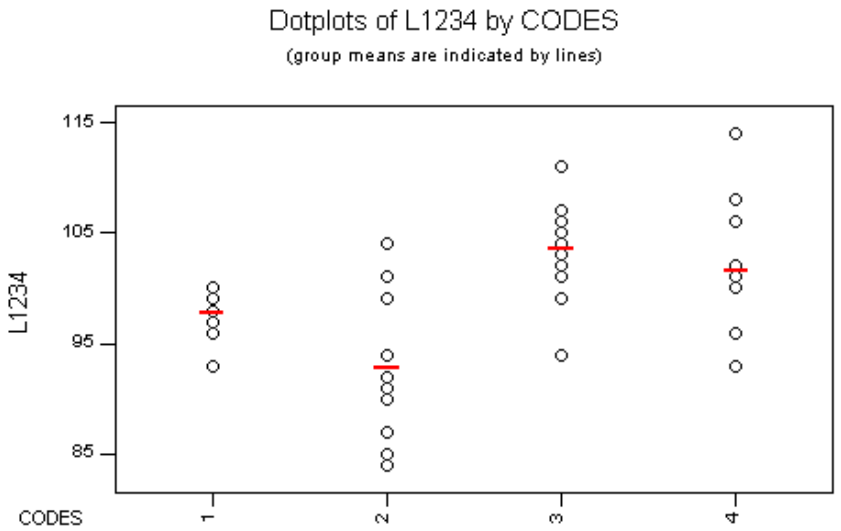
(a) Read again the last sentence in the article. Quote the sentence earlier in the article referring to this point. Using statistical terminology, explain what this sentence is telling us about how the margin of error has been determined.

(b) Name and describe the source of any two non-sampling errors discussed in the article.

(c) What does the article say about the reported margin of error for subgroups in a poll?

(d) What does the article say about the reported margin of error for estimates which are close to 0?

Computer output for question 4:



One-way Analysis of Variance

Analysis of Variance for L1234

Source	DF	SS	MS	F	P
CODES	3	804.8	268.2	10.76	0.000
Error	44	1096.5	24.9		
Total	47	1901.3			

Level	N	Mean	StDev	Individual 95% CIs For Mean Based on Pooled StDev
1	12	97.75	2.09	(-----*----)
2	12	92.75	6.66	(-----*----)
3	12	103.50	4.30	(-----*-----)
4	12	101.50	5.70	(-----*-----)

Pooled StDev = 4.99 — 90.0 95.0 100.0 105.0

Tukey's pairwise comparisons

Family error rate = 0.0500
Individual error rate = 0.0105

Critical value = 3.78

Intervals for (column level mean) - (row level mean)

	1	2	3
2	-0.447 10.447		
3	-11.197 -0.303	-16.197 -5.303	
4	-9.197 1.697	-14.197 -3.303	-3.447 7.447