SEMESTER 2, SESSION 2014/2015

SSCE/SSE2193 Engineering Statistics

Supplementary Exercise 3: Estimation

1. The deflection temperature under load for two different types of plastic pipe is being investigated. Two random samples with size 8 and 9 pipe specimens are tested, and the deflection temperature observed are reported here (in °C):

Type 1	25	30	15	19	30	24	10	12	
Type 2	20	22	15	8	25	12	14	10	9

Assume that the deflection temperature follows normal distribution.

i. Find the estimates of the mean and the standard deviation of deflection temperature for each type.

ii. Show that the 90% confidence interval for the ratio of the two variances of deflection temperature is given as (0.4752, 6.2039)°C.

iii. Using the answer in (ii), determine whether the two variances are equal. Justify your answer.

Final, Sem 1, 12/13

2. A production process will be declared of high quality if it produces no more than 2700 defect products per million or, equivalently, 0.0027. There are two processes. Among 2500 products selected at random from Process I, there are 4 defect products. On the other hand, among 2500 products from Process II there is only 1 defect.

i. Construct a 90% confidence interval for the proportion of defect products from Process I.

ii. Construct a 99% confidence interval for the difference between the proportions of defect products from Process I and Process II.

Final, Sem 1, 12/13

3. Sodium content in organic cornflakes depends on fertilization method. A new fertilization method has been developed. The following data of sodium content (in milligrams) issued from the new method of fertilization were obtained from a sample of ten 300-grams organic cornflakes boxes:

130.72	128.33	128.24	129.65	130.14
129.29	128.71	129.00	128.77	129.64

Assume the sodium content is normally distributed.

i. Construct a 95% confidence interval of the mean sodium content.

ii. Construct a 99% confidence interval of the variance of sodium content.

iii. From the result in part (b. ii.), could you conclude that the variance equals 1? Verify your answer.

Final, Sem 2, 12/13

4. a) It is given that the 95% confidence interval for the mean lifespan of Energy lightbulbs is (1023.3 hour, 1101.7 hour). This interval is based on results from a random sample of 121 light bulbs. Hence, find the 99% confidence interval for the mean lifespan of this brand of light bulbs.

   b) A manufacturer wants to assess the percentage of defective output in a large batch produced by a cutting machine. A random sample of 300 output was tested and found that 45 of them were defective. Calculate a 98% confidence interval for the percentage of defective output in the complete batch.

Final, Sem 2, 07/08

5. Two different analytical tests are used to determine the impurity level in steel alloys. Ten specimens are tested using both procedures, and results are tabulated as follows:

Specimen	Test 1	Test 2
1	1.3	1.5
2	1.4	1.2
3	1.2	1.3
4	1.6	1.8
5	1.5	1.3
6	1.7	1.4
7	1.8	1.4
8	1.4	1.3
9	1.3	1.6
10	1.5	1.7

   i. Assume the impurity levels are normally distributed, construct a 95% confidence interval for the ratio of variances of impurity levels measured using the two different analytical tests.
   ii. Based on your answer in part (i), are you 95% confident that the variances of impurity levels are different when measured using different analytical tests? Verify your answer.

Final, Sem 2, 09/10

6. A traffic engineer conducted a study on the number of speed limit violation among Malaysian drivers. He posted a speed limit of 50 km/h and monitored the speed of 100 randomly selected vehicles and found that 27 of them violated the speed limit. The speed limit was raised to 70 km/h and he monitored the speed of 100 randomly selected vehicles and found 19 vehicles violated the speed limit. Calculate a 95% confidence interval for the difference between the two proportions of vehicles violating the speed limit, before and after the speed limit was raised. Then, based on your answer, do you think that it is likely that the two true proportions of vehicles violating the speed limit are the same? Justify your answer.

Final, Sem 2, 10/11

7. In semiconductor manufacturing, wet chemical etching is used to remove silicon from the backs of wafers prior to metallization. Two different etching solutions have been compared, using two random samples of 8 wafers. The observed etch rates are given in the following table

Observation Number	Solution 1	Solution 2
1	91.50	89.19
2	94.18	90.95
3	92.18	90.46
4	95.39	93.21
5	91.79	97.19
6	89.07	97.04
7	94.72	91.07
8	89.21	92.75

Suppose that the two samples are independent and come from populations which are normally distributed. Also, assume that their population variances are equal. Construct a 95% confidence interval for the difference between the two mean etching rates of the two solutions.

Final, Sem 2, 10/11

8. In a random sample of 500 adults and 400 teenagers who watched a certain ASTRO program, 200 adults and 250 teenagers indicated that they enjoyed the program.

   a) Determine the point estimates of the true proportions
      i. of all adults who watched the ASTRO program and enjoyed it.
      ii. of all teenagers who watched the ASTRO program and did not enjoy it.
   b) Next, construct a 95% confidence interval for the difference in proportions of all adults and all teenagers who watched the ASTRO program but did not enjoy it.
   c) Interpret your answer in part (b).

Final, Sem 1, 11/12

9. Measurements of the diameters of a random sample of 13 ball bearings made by machine *X* during one week showed a mean of 8.22 mm and a standard deviation of 0.38 mm. However, other measurements of the diameters of a random sample of 11 ball bearings made by machine *Y* during the same week showed a mean of 7.68 mm and a standard deviation of 0.42 mm. Assuming the diameters are normally distributed with equal variance,
   a) Construct a 99% confidence interval for the difference in the true mean diameters of ball bearings made by the two machines.
   b) Based on your answer in part (a), are you 99% confident that the true mean diameters of ball bearings made by machines *X* and *Y* are not equal? Justify your answer.

Final, Sem 1, 11/12

10. Journal of Science and Technology published a study on the ammonia levels in the air near an exit ramp of a highway tunnel in the state of Selangor. The data in the table represent daily ammonia concentrations (in unit) on twelve randomly selected days in June 2011.

1.53	1.37	1.51	1.55	1.40	1.49
1.50	1.45	1.42	1.48	1.47	1.41

a) Construct a 99% confidence interval for mean daily ammonia level in the tunnel assuming that the ammonia level follows a normal distribution with variance of 0.25 unit^2.
b) Construct a 95% confidence interval for the standard deviation of daily ammonia level in the tunnel.

Final, Sem 2, 11/12

11. A researcher claims that at least 15% of all football helmets have manufacturing flaws that could potentially cause injury to the wearer. A sample of 250 helmets revealed that 20 helmets contained such defects. Construct a 95% confidence interval for the true proportion of the defect helmets.

Final, Sem 2, 11/12

12. A new manufacturing process of component parts is being considered. Samples were taken using both the existing and the new processes so as to determine whether the new process improves the proportion of defective components. 1425 of 1500 components from the existing process and 1920 of 2000 components from the new process were found to be non defective.

$$P_1 = \frac{75}{1500} = 0.05, P_2 = \frac{80}{2000} = 0.04 \text{ and } P_1 - P_2 = 0.05 - 0.04 = 0.01$$

a. Find a 99% confidence interval for the true difference in the fraction of defectives between the existing and the new processes?
b. Based on your answer in (a), is there any significant difference between the existing and the new processes? Justify?

Test 1, Sem 1, 08/09

13. The compressive strength of parts made from a composite material is known to be approximately normally distributed. A scientist, using the testing device for the first time, obtains the compressive strength (in Pascal) of 16 specimens:

95	102	105	107	109	110	111	112
134	135	136	139	150	155	156	100

a. What is the best estimate for the true mean and variance of compressive strength?
b. Construct a 95% confidence interval on the variability of the compressive strength of the parts.

c. Assume that the compressive strength of parts is normally distributed with a standard deviation of 25 Pascal, construct a 90% confidence interval for the true mean compressive strength.

Test 1, Sem 1, 08/09

14. Carbonated drink bottles are filled by an automated filling machine. Assume that the fill volume is normally distributed. A random sample of size n was drawn from this process which gives the mean fill volume of 0.497 liter and variance of 0.005 liter2. Calculate the maximum size of a random sample n needed so that the upper limit of 99% confidence interval on the mean fill volume of all carbonated drink bottles produced by this factory is at most 0.55 liter? [Hint: $n < 30$].

Test 1, Sem 1, 09/10

15. Two machines are used for filling plastic bottles with a net volume of 16.0 ounces. The fill volume can be assumed normal. A random sample of 10 bottles is taken from the output of each machine, and the fill volume readings of the bottles are as follows:

Machine 1		Machine 2	
16.03	16.01	16.02	16.03
16.04	15.96	15.97	16.04
16.05	15.98	15.96	16.02
16.05	16.02	16.01	16.01
16.02	15.99	15.99	16.00

a. What is the standard deviation of sampling distribution of the sample mean for Machine 1?
b. Find a 95% confidence interval on the difference in means of the fill volume for the two machines.
c. Find a 90% confidence interval on the variance of the fill volume for Machine 2.

Test 1, Sem 1, 09/10

16. A survey carried out by the professional engineers describes several characteristics of fuel rods used in a reactor owned by an electric utility in Damansara. Measurements on the percentage of enrichment of 12 rods were reported as follows:

2.94	3.00	2.90	2.75	3.00	2.95
2.90	2.75	2.95	2.82	2.81	3.05

Assume that the percentage of enrichment follows normal distribution.

i. What is the point estimate for the mean of enrichment of fuel rods?
ii. Construct a 99% confidence interval on the mean of enrichment of fuel rods. What can you infer from the statement that the percentage of enrichment is 2.95 percent?
iii. Construct a 98% confidence interval for the standard deviation of enrichment of fuel rods.

Test 2, Sem 1, 12/13

17. A university administrator is investigating the proportion of students who have shown interest in using the latest interactive learning software. He gave questionnaires to a thousand randomly selected students and found out that 518 students have shown interest in using the software.

    a. Help the administrator to construct a 90% confidence interval for the population proportion of students who have shown interest in using the latest interactive learning software.
    b. Based on the answer in part (a), why do you think the administrator should not be 90% confident that more than half of students would show interest in using the software?

    Test 2, Sem 2, 12/13

18. Twenty randomly selected observations of breakdown voltage were collected and the variance was recorded as 33489 unit2. Assuming the breakdown voltage is normally distributed, construct a 95% confidence interval for the standard deviation of breakdown voltage.

    Test 2, Sem 2, 12/13

19. Charpy V-notch (CVN) is a technique to measure impact energy of temperature on metallic materials. Ten measurements of impact energy (J) on specimens of A238 type steel cut at 60 ^{o}C are as follows:

    64.1 64.7 64.5 64.6 64.5 64.3 64.6 64.8 64.2 64.3

    Assume that impact energy is normally distributed. Find the 95% confidence interval for the true mean impact energy of A238 steel at 60 ^{o}C .

    Test 2, Sem 2, 11/12

20. The diameter (in millimeters) of steel rods manufactured on two different extrusion machines is being investigated. Two random samples are selected. The sample mean and sample variance for the first sample of size 10 are given by 90 and 5 respectively. The sample mean and sample variance for the second sample of size 15 are given by 87 and 4 respectively. Assume that the population means for the diameters from both extrusion machines are equal and that the data are drawn from a normal population.
    a. Construct a 95% confidence interval for the difference in mean rod diameter.
    b. From the interval constructed in (a), do you agree that there is a difference in mean rod diameter of steel rods from the two machines? Justify.

    Test 2, Sem 2, 11/12

21. (a) A mechanical engineer conducted a test on the lengths of 49 randomly selected steel rods and found that the mean length is 102.5 cm and the variance is 114.49 cm^2. What is his point estimate for the population mean and construct a 98% confidence interval for the population mean.

b) A quality control officer from SIRIM conducted a study on the life of 300 randomly selected memory chips produced by an electronic company and found that 9 are defective. Construct a 99 percent confidence interval for the true proportion of defective chips produced by the electronic company.

Test 2, Sem 1, 11/12

22. Pemanis Sdn. Bhd. in Bandar Baru Bangi is a soft drink bottling company. Carbonated drink bottles are filled up to 5 liters by an automated filling machine. Assume that the fill volume is normally distributed. The following fill volumes are the results of 10 bottles selected randomly from the bottling process:

5.061	5.083	5.058	5.075	5.049
5.037	5.048	5.097	5.069	5.071

a. Construct a 95% confidence interval for the mean fill volume of all filled bottles.
b. Construct a 90% confidence interval for the variance fill volume of all filled bottles.

Test 2, Sem 1, 11/12

Answers to Supplementary Exercise 3

1. (i) $\bar{X}_1 = 20.625, \bar{X}_2 = 15, s_1 = 7.8182, s_2 = 6.062$
   (iii) Since $0.4752 < \frac{\sigma_1^2}{\sigma_2^2} < 6.2039$, the ratio includes 1, therefore $\sigma_1^2 \approx \sigma_2^2$.
2. (i) (0.000285,0.002915)
   (ii) (- 0.001102, 0.003502)
3. (i) (128.6788, 129.8192) (ii) (0.2424, 3.2955) (iii) Yes. B'cos the CI contains 1.
4. (a) (1010.984,1114.016) (b) (0.102,0.198)
5. (i) (0.2310, 3.7510)
   (ii) No. The CI contains 1 implying no significant difference in variances.
6. (-0.0361, 0.1961); Yes, the true proportions are likely the same. The CI contains 0.
7. Use *t* and s_p ; (-3.3742, 2.4192)
8. (a) i. 0.4 (a) ii. 0.375 b. (0.1610; 0.2890)
   (c) There is a 95% confidence that the adult viewers are less likely to enjoy the ASTRO program as compared to the teenage viewers (i.e. more proportions of adults did NOT enjoy the program).
9. (a) (0.07958, 1.0004)
   (b) Yes, the population means are NOT equal. The CI does not contain 0.
10. (a) (1.0932, 1.8368) (b) (0.03944, 0.09453)

11. (0.04637, 0.1136)
12. (a) $(-0.0084, 0.0284)$
    (b) No difference. The CI contains 0.
13. (a) 122.25, 432.4653 (b) $(235.9931, 1035.9277)$ (c) $(111.9694, 132.5306)$
14. $n = 16$
15. (a) 0.009582 (b) $(-0.0164, 0.0364)$ (c) (0.0003459, 0.00176)
16. (i) 2.901
    (ii) (2.8127, 2.9907). Inference: The statement can be acceptable with 99% confidence since the 99% CI contains the value 2.95%.
    (iii) $(0.0662, 0.1886)$
17. (a) (0.4920,0.5440)
    (b) The lower limit of CI is less than 0.5, thus not more than half of students would likely show interest in using the software.
18. (139.1704, 267.2774)
19. (64.298, 64.622)
20. (a) (1.230, 4.770)
    (b) Yes. The CI does not contain 0 implying a significant difference in means exists.
21. (a) (98.9441,106.0559) (b) (0.00463,0.05537)
22. (a) $(5.052,\ 5.078)$ (b) $(1.71,\ 8.70) \times 10^{-4}$