Tutorial 5: Engineering Statistics

1. Find the value of $z_{\alpha/2}$ to use in expression (5.1) to construct a confidence interval with level

   a. 95%

   b. 98%

   c. 99%

   d. 80%

5. In a sample of 100 steel wires the average breaking strength is 50 kN, with a standard deviation of 2 kN.

   a. Find a 95% confidence interval for the mean breaking strength of this type of wire.

   b. Find a 99% confidence interval for the mean breaking strength of this type of wire.

   c. An engineer claims that the mean breaking strength is between 49.7 kN and 50.3 kN. With what level of confidence can this statement be made?

   d. How many wires must be sampled so that a 95% confidence interval specifies the mean breaking strength to within ±0.3 kN?

   e. How many wires must be sampled so that a 99% confidence interval specifies the mean breaking strength to within ±0.3 kN?

7. The capacities (in ampere-hours) were measured for a sample of 120 batteries. The average was 178 and the standard deviation was 14.

   a. Find a 95% confidence interval for the mean capacity of batteries produced by this method.

   b. Find a 99% confidence interval for the mean capacity of batteries produced by this method.

   c. An engineer claims that the mean capacity is between 176 and 180 ampere-hours. With what level of confidence can this statement be made?

   d. Approximately how many batteries must be sampled so that a 95% confidence interval will specify the mean to within ± 2 ampere-hours?

   e. Approximately how many batteries must be sampled so that a 99% confidence interval will specify the mean to within ± 2 ampere-hours?

11. The sugar content in a one-cup serving of a certain breakfast cereal was measured for a sample of 140 servings. The average was 11.9 g and the standard deviation was 1.1 g.

   a. Find a 95% confidence interval for the mean sugar content.

   b. Find a 99% confidence interval for the mean sugar content.

   c. What is the confidence level of the interval (11.81, 11.99)?

   d. How large a sample is needed so that a 95% confidence interval specifies the mean to within ± 0.1?

   e. How large a sample is needed so that a 99% confidence interval specifies the mean to within ± 0.1?

5. The article "The Functional Outcomes of Total Knee Arthroplasty" (R. Kane, K. Saleh, et al., *Journal of Bone and Joint Surgery*, 2005:1719–1724) reports that out of 10,501 surgeries, 859 resulted in complications within six months of surgery.

a. Find a 95% confidence interval for the proportion of surgeries that result in complications within six months.

b. Find a 99% confidence interval for the proportion of surgeries that result in complications within six months.

c. A surgeon claims that the rate of complications is less than 8.5%. With what level of confidence can this claim be made?

13. A sociologist is interested in surveying workers in computer-related jobs to estimate the proportion of such workers who have changed jobs within the past year.

a. In the absence of preliminary data, how large a sample must be taken to ensure that a 95% confidence interval will specify the proportion to within ±0.05?

b. In a sample of 100 workers, 20 of them had changed jobs within the past year. Find a 95% confidence interval for the proportion of workers who have changed jobs within the past year.

c. Based on the data in part (b), estimate the sample size needed so that the 95% confidence interval will specify the proportion to within ±0.05.

1. Find the value of $t_{n-1,\alpha/2}$ needed to construct a two-sided confidence interval of the given level with the given sample size:

   a. Level 90%, sample size 12.

   b. Level 95%, sample size 7.

   c. Level 99%, sample size 2.

   d. Level 95%, sample size 29.

5. The article "Wind-Uplift Capacity of Residential Wood Roof-Sheathing Panels Retrofitted with Insulating Foam Adhesive" (P. Datin, D. Prevatt, and W. Pang, *Journal of Architectural Engineering*, 2011:144–154) presents a study of the failure pressures of roof panels. Following are the failure pressures, in kPa, for five panels constructed with 6d smooth shank nails. These data are consistent with means and standard deviations presented in the article.

   3.32   2.53   3.45   2.38   3.01

   Find a 95% confidence interval for the mean failure pressure for this type of roof panel.

7. The article "An Automatic Visual System for Marble Tile Classification" (L. Carrino, W. Polini, and S. Turchetta, *Journal of Engineering Manufacture*, 2002:1095–1108) describes a measure for the shade of marble tile in which the amount of light reflected by the tile is measured on a scale of 0–255. A perfectly black tile would reflect no light and measure 0, and a perfectly white tile would measure 255. A sample of nine Mezza Perla tiles were measured, with the following results:

204.999   206.149   202.102   207.048   203.496
206.343   203.496   206.676   205.831

Is it appropriate to use the Student's t statistic to construct a 95% confidence interval for the mean shade of Mezza Perla tile? If so, construct the confidence interval. If not, explain why not.

1. To study the effect of curing temperature on shear strength of a certain rubber compound, 80 specimens were cured at 150°C and 95 were cured at 130°C. The specimens cured at 150°C had an average shear strength of 620 psi, with a standard deviation of 20 psi. Those cured at 130°C had an average shear strength of 750 psi, with a standard deviation of 30 psi. Find a 95% confidence interval for the difference between the mean shear strengths of specimens cured at the two temperatures.

3. The article "Inconsistent Health Perceptions for US Women and Men with Diabetes" (M. McCollum, L. Hansen, et al., *Journal of Women's Health*, 2007:1421–1428) presents results of a survey of adults with diabetes. The average body mass index (BMI) in a sample of 1559 men was 30.4, with a standard deviation of 0.6. The average BMI in a sample of 1924 women was 31.1 with a standard deviation of 0.2. Find a 99% confidence interval for the difference in mean BMI between men and women with diabetes.

1. In a test of the effect of dampness on electric connections, 100 electric connections were tested under damp conditions and 150 were tested under dry conditions. Twenty of the damp connections failed and only 10 of the dry ones failed. Find a 90% confidence interval for the difference between the proportions of connections that fail when damp as opposed to dry.

5. Crash testing is a highly expensive procedure to evaluate the ability of an automobile to withstand a serious accident. A simple random sample of 12 small cars were subjected to a head-on collision at 40 miles per hour. Of them 8 were "totaled," meaning that the cost of repairs is greater than the value of the car. Another sample of 15 large cars were subjected to the same test, and 5 of them were totaled. Find a 95% confidence interval for the difference in the proportions of small cars and large cars that are totaled.

1. In a study comparing various methods of gold plating, 7 printed circuit edge connectors were gold-plated with control-immersion tip plating. The average gold thickness was 1.5 μm, with a standard deviation of 0.25 μm. Five connectors were masked and then plated with total immersion plating. The average gold thickness was 1.0 μm, with a standard deviation of 0.15 μm. Find a 99% confidence interval for the difference between the mean thicknesses produced by the two methods.

3. In an experiment involving the breaking strength of a certain type of thread used in personal flotation devices, one batch of thread was subjected to a heat treatment for 60 seconds and another batch was treated for 120 seconds. The breaking strengths (in N) of ten threads in each batch were measured. The results were

   60 seconds: 43 52 52 58 49 52 41 52 56 54

   120 seconds: 59 55 59 66 62 55 57 66 66 51

   Find a 99% confidence interval for the difference in the mean strengths between threads treated for 60 seconds and those treated for 120 seconds.

Section 5.7: Confidence Intervals with Paired Data

1. The article "Simulation of the Hot Carbonate Process for Removal of CO_2 and H_2S from Medium Btu Gas" (K. Park and T. Edgar, *Energy Progress*, 1984:174–180) presents an equation used to estimate the equilibrium vapor pressure of CO_2 in a potassium carbonate solution. The actual equilibrium pressure (in kPa) was measured in nine different reactions and compared with the value estimated from the equation. The results are presented in the following table:

Reaction	Estimated	Experimental	Difference
1	45.10	42.95	2.15
2	85.77	79.98	5.79
3	151.84	146.17	5.67
4	244.30	228.22	16.08
5	257.67	240.63	17.04
6	44.32	41.99	2.33
7	84.41	82.05	2.36
8	150.47	149.62	0.85
9	253.81	245.45	8.36

Find a 95% confidence interval for the mean difference between the estimated and actual pressures.

7. For a sample of nine automobiles, the mileage (in 1000s of miles) at which the original front brake pads were worn to 10% of their original thickness was measured, as was the mileage at which the original rear brake pads were worn to 10% of their original thickness. The results are given in the following table.

Automobile	Front	Rear
1	32.8	41.2
2	26.6	35.2
3	35.6	46.1
4	36.4	46.0
5	29.2	39.9
6	40.9	51.7
7	40.9	51.6
8	34.8	46.1
9	36.6	47.3

Find a 95% confidence interval for the difference in mean lifetime between the front and rear brake pads.

1. Find the following values.

a. $\chi^2_{12,.025}$

b. $\chi^2_{12,.975}$

c. $\chi^2_{5,.005}$

d. $\chi^2_{5,.995}$

e. $\chi^2_{22,.1}$

f. $\chi^2_{22,.9}$

7. Boxes of cereal are labeled as containing 14 ounces. Following are the weights, in ounces, of a sample of 12 boxes. Assume that the population is normally distributed.

14.02	13.97	14.11	14.12	14.10	14.02
14.15	13.97	14.05	14.04	14.11	14.12

a. Find the sample standard deviation s.

b. Construct a 98% confidence interval for population standard deviation σ.

1. A sample of 25 resistors, each labeled 100 Ω, had an average resistance of 101.4 Ω with a standard deviation of 2.3 Ω. Assume the resistances are normally distributed.

   a. Find a 95% prediction interval for the resistance of a single resistor.

   b. Find a tolerance interval for the resistance that includes 90% of the resistors with 95% confidence.

5. Five measurements are taken of the octane rating for a particular type of gasoline. The results (in percent) are 87.0, 86.0, 86.5, 88.0, 85.3.

   a. Find a 95% prediction interval for a single measurement.

   b. Find a tolerance interval for the pH that includes 90% of the measurements with 99% confidence.