Tutorial 6: Engineering Statistics

Section 6.1: Large Sample Tests for a Population Mean

1. In an experiment to measure the lifetimes of parts manufactured from a certain aluminum alloy, 73 parts were loaded cyclically until failure. The mean number of kilocycles to failure was 783, and the standard deviation was 120. Let μ represent the mean number of kilocycles to failure for parts of this type. A test is made of $H_0: \mu \leq 750$ versus $H_1: \mu > 750$.

a. Find the P-value.

b. Either the mean number of kilocycles to failure is greater than 750, or the sample is in the most extreme _____% of its distribution.

5. Recently many companies have been experimenting with telecommuting, allowing employees to work at home on their computers. Among other things, telecommuting is supposed to reduce the number of sick days taken. Suppose that at one firm, it is known that over the past few years employees have taken a mean of 5.4 sick days. This year, the firm introduces telecommuting. Management chooses a simple random sample of 80 employees to follow in detail, and, at the end of the year, these employees average 4.5 sick days with a standard deviation of 2.7 days. Let μ represent the mean number of sick days for all employees of the firm.

a. Find the P-value for testing $H_0: \mu \geq 5.4$ versus $H_1: \mu < 5.4$.

b. Do you believe it is plausible that the mean number of sick days is at least 5.4, or are you convinced that it is less than 5.4? Explain your reasoning.

Section 6.2: Drawing Conclusions from the Results of Hypothesis Tests

5. True or false: If $P = 0.02$, then

a. The result is statistically significant at the 5% level.

b. The result is statistically significant at the 1% level.

c. The null hypothesis is rejected at the 5% level.

d. The null hypothesis is rejected at the 1% level.

11. It is desired to check the calibration of a scale by weighing a standard 10 g weight 100 times. Let μ be the population mean reading on the scale, so that the scale is in calibration if $\mu = 10$. A test is made of the hypotheses $H_0: \mu = 10$ versus $H_1: \mu \neq 10$. Consider three possible conclusions: (i) The scale is in calibration. (ii) The scale is out of calibration. (iii) The scale might be in calibration.

a. Which of the three conclusions is best if H_0 is rejected?

b. Which of the three conclusions is best if H_0 is not rejected?

c. Is it possible to perform a hypothesis test in a way that makes it possible to demonstrate conclusively that the scale is in calibration? Explain.

Section 6.3: Tests for a Population Proportion

1. Integrated circuits consist of electric channels that are etched onto silicon wafers. A certain proportion of circuits are defective because of "undercutting," which occurs when too much material is etched away so that the channels, which consist of the unetched portions of the wafers, are too narrow. A redesigned process, involving lower pressure in the etching chamber, is being investigated. The goal is to reduce the rate of undercutting to less than 5%. Out of the first 1000 circuits manufactured by the new process, only 35 show evidence of undercutting. Can you conclude that the goal has been met?

7. In a sample of 150 households in a certain city, 110 had high-speed internet access. Can you conclude that more than 70% of the households in this city have high-speed internet access?

Section 6.4: Small-sample Tests for a Population Mean

3. A new centrifugal pump is being considered for an application involving the pumping of ammonia. The specification is that the flow rate be more than 5 gallons per minute (gpm). In an initial study, eight runs were made. The average flow rate was 6.5 gpm and the standard deviation was 1.9 gpm. If the mean flow rate is found to meet the specification, the pump will be put into service.

a. State the appropriate null and alternate hypotheses.

b. Find the P-value.

c. Should the pump be put into service? Explain.

7. Specifications call for the wall thickness of two-liter polycarbonate bottles to average 4.0 mils. A quality control engineer samples 7 two-liter polycarbonate bottles from a large batch and measures the wall thickness (in mils) in each. The results are: 3.999, 4.037, 4.116, 4.063, 3.969, 3.955, and 4.091. It is desired to test $H_0 : \mu = 4.0$ versus $H_1 : \mu \neq 4.0$.

a. Make a dotplot of the seven values.

b. Should a Student's t test be used to test H_0? If so, perform the test. If not, explain why not.

c. Measurements are taken of the wall thicknesses of seven bottles of a different type. The measurements this time are: 4.004, 4.225, 3.924, 4.052, 3.975, 3.976, and 4.041. Make a dotplot of these values.

d. Should a Student's t test be used to test $H_0 : \mu = 4.0$ versus $H_1 : \mu \neq 4.0$? If so, perform the test. If not, explain why not.

Section 6.5: Large-sample Tests for the Difference Between Two Means

1. The article "Capillary Leak Syndrome in Children with C4A-Deficiency Undergoing Cardiac Surgery with Cardiopulmonary Bypass: A Double-Blind, Randomised Controlled Study" (S. Zhang, S. Wang, et al., *Lancet*, 2005:556–562) presents the results of a study of the effectiveness of giving blood plasma containing complement component C4A to pediatric cardiopulmonary bypass patients. Of 58 patients receiving C4A-rich plasma, the average length of hospital stay was 8.5 days and the standard deviation was 1.9 days. Of 58 patients receiving C4A-free plasma, the average length of hospital stay was 11.9 days and the standard deviation was 3.6 days. Can you conclude that the mean hospital stay is shorter for patients receiving C4A-rich plasma?

5. In a test to compare the effectiveness of two drugs designed to lower cholesterol levels, 75 randomly selected patients were given drug A and 100 randomly selected patients were given drug B. Those given drug A reduced their cholesterol levels by an average of 40 with a standard deviation of 12, and those given drug B reduced their levels by an average of 42 with a standard deviation of 15. The units are milligrams of cholesterol per deciliter of blood serum. Can you conclude that the mean reduction using drug B is greater than that of drug A?

Section 6.6: Tests for the Difference Between Two Proportions

1. Two extrusion machines that manufacture steel rods are being compared. In a sample of 1000 rods taken from machine 1, 960 met specifications regarding length and diameter. In a sample of 600 rods taken from machine 2, 582 met the specifications. Machine 2 is more expensive to run, so it is decided that machine 1 will be used unless it can be convincingly shown that machine 2 produces a larger proportion of rods meeting specifications.

a. State the appropriate null and alternate hypotheses for making the decision as to which machine to use.

b. Compute the P-value.

c. Which machine should be used?

7. To test the effectiveness of protective packaging, a firm shipped out 1200 orders in regular light packaging and 1500 orders in heavy-duty packaging. Of the orders shipped in light packaging, 20 arrived in damaged condition, while of the orders shipped in heavy-duty packaging, 15 arrived in damaged condition. Can you conclude that heavy-duty packaging reduces the proportion of damaged shipments?

Section 6.7: Small-sample Tests for the Difference Between Two Means

1. A crayon manufacturer is comparing the effects of two kinds of yellow dye on the brittleness of crayons. Dye B is more expensive than dye A, but it is thought that it might produce a stronger crayon. Four crayons are tested with each kind of dye, and the impact strength (in joules) is measured for each. The results are as follows:

Dye A:	1.0	2.0	1.2	3.0
Dye B:	3.0	3.2	2.6	3.4

a. Can you conclude that the mean strength of crayons made with dye B is greater than that of crayons made with dye A?

b. Can you conclude that the mean strength of crayons made with dye B exceeds that of crayons made with dye A by more than 1 J?

13. In an experiment to test the effectiveness of a new sleeping aid, a sample of 12 patients took the new drug, and a sample of 14 patients took a commonly used drug. Of the patients taking the new drug, the average time to fall asleep was 27.3 minutes with a standard deviation of 5.2 minutes, and for the patients taking the commonly used drug the average time was 32.7 minutes with a standard deviation of 4.1 minutes. Can you conclude that the mean time to sleep is less for the new drug?

Section 6.8: Tests with Paired Data

3. A dry etch process is used to etch silicon dioxide (SiO_2) off of silicon wafers. An engineer wishes to study the uniformity of the etching across the surface of the wafer. A total of 10 wafers are sampled after etching, and the etch rates (in Å/min) are measured at two different sites, one near the center of the wafer, and one near the edge. The results are presented in the following table.

Wafer	Center	Edge
1	586	582
2	568	569
3	587	587
4	550	543
5	543	540
6	552	548
7	562	563
8	577	572
9	558	559
10	571	566

Can you conclude that the etch rates differ between the center and the edge?

7. The compressive strength, in kilopascals, was measured for concrete blocks from five different batches of concrete, both three and six days after pouring. The data are presented in the following table.

	Batch				
	1	2	3	4	5
After 3 days	1341	1316	1352	1355	1327
After 6 days	1376	1373	1366	1384	1358

Can you conclude that the mean strength after six days is greater than the mean strength after three days?