ME 794 Statistical Design of Experiments

Tutorial 1

Comparative Experiments (t-test and z-test) [Ungraded]

Section 1: *z-test problems*

1. The breaking strength of a fiber is required to be at least 150 psi. Past experience has indicated that the standard deviation of breaking strength is $\sigma = 3$ psi. A random sample of 4 specimens is tested, and the results are $y1 = 145$, $y2 = 153$, $y3 = 150$, and $y4 = 147$.
   a. State the hypothesis that you think should be tested in this experiment.
   b. Test these hypotheses using $\alpha = 0.05$. What are your conclusions (Part is accepted or rejected)? {α=0.05 implies range [-1.96,1.96]}
   c. Construct a 95 percent confidence interval on the mean breaking strength.

2. Two machines are used for filling plastic bottles with a net volume of 16.0 ounces. The filling processes can be assumed to be normal, with standard deviations of σ_1=0.015 and σ_2=0.018. The quality engineering department suspects that both machines fill to the same net volume, whether or not this volume is 16.0 ounces. An experiment is performed by taking a random sample from the output of each machine.

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. State the hypotheses that should be tested in this experiment. Will the alternate hypothesis be one-sided or two-sided?
   b. Test these hypotheses using α=0.05 and state if we reject or not the null hypothesis. You can make use of the table below.

Desired Confidence Interval	Z-score
90%	1.645
95%	1.96
99%	2.567

   c. Find a 95 percent confidence interval on the difference in mean fill volume for the two machines.

3. The viscosity of a liquid detergent is supposed to average 800 centistokes at 25°C. A random sample of 16 batches of detergent is collected, and the average viscosity is 812. Suppose we know that the standard deviation of viscosity is σ=25 centistokes.
   a. State the hypotheses that should be tested.

b. Test these hypotheses using $\alpha=0.05$. What do you conclude on the null hypotheses? Do you accept or reject the null hypotheses?
c. Find a 95 percent confidence interval on the mean.

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<u>Section 2:</u> *t-test problems*

1. <u>Consider the following computer output</u>
   One sample
   Test: $\mu=30$ vs $\mu\neq30$
   The assumed standard deviation =1.2

N	Mean	SE Mean	95% CI
16	31.200	0.3000	(30.6120,31.7888)

   a. Is this a one-sided or two-sided test?
   b. Use the output and the normal table to find a 99% confidence interval on the mean. (Hint: use the t-test)

2. The following are the burning times (in minutes) of chemical flares of two different formulations. Using $\alpha = 0.05$, test the hypothesis that the mean burning times are equal and state whether we reject the null hypothesis or not. (Hint: Use a two-sample t-test, assume common variance)

Type 1	**Type 2**
65	64
67	56
57	59
66	65
70	69

3. Photoresist is a light-sensitive material applied to semiconductor wafers so that the circuit pattern can be imaged onto the wafer. After application, the coated wafers are baked to remove the solvent in the photoresist mixture and to harden the resist. Here are measurements of photoresist thickness (in kÅ) for eight wafers baked at two different temperatures. Assume that all the runs were made in random order.

95 °C	**100 °C**
11.18	7.45
11.74	7.015
11.30	7.42
10.75	8.14

   Find a 95% confidence interval on the difference in means. Provide a practical interpretation of this interval.

4. The shelf life of a carbonated beverage is of interest. Ten bottles are randomly selected and tested, and the following results are obtained:

Days	
108	138
124	163
124	159
106	134
115	139

   a. We would like to demonstrate that the mean shelf life exceeds 120 days. Set up appropriate hypotheses for investigating this claim.
   b. Test these hypotheses using α=0.01. What do you conclude on the null hypotheses? Do you accept or reject the null hypotheses?
   c. Construct a 99 percent confidence interval on the mean shelf life.

5. Front housings for cell phones are manufactured in an injection molding process. The time the part is allowed to cool in the mold before removal is thought to influence the occurrence of a particularly troublesome cosmetic defect, flow lines, in the finished housing. After manufacturing, the housings are inspected visually and assigned a score between 1 and 10 based on their appearance, with 10 corresponding to a perfect part and 1 corresponding to a completely defective part. An experiment was conducted using two cool-down times, 10 and 20 seconds, and 5 housings were evaluated at each level of cool-down time. All 10 observations in this experiment were run in random order. The data are as follows:

10 seconds	**20 seconds**
1	6
6	8
8	5
2	8
3	7

   a. Is there evidence to support the claim that the longer cool-down time results in fewer appearance defects? Use α=0.05.
   b. Find a 95 percent confidence interval on the difference in means.

6. <u>Answer the following:</u>
   a. Develop an equation for finding a 100(1 - α) percent confidence interval on the difference in the means of two normal distributions where $\sigma_1^2 \neq \sigma_2^2$. Also, for the distribution, state the number of degrees of freedom.
   b. Now, for the obtained equation, use the following data and find a 95% confidence interval and calculate the number of degrees of freedom.

	Modified Mortar	**Unmodified Mortar**
1	17	16.75
2	16.5	16.25
3	17.25	17.5