

MSA 8190 Statistical Foundations

Fall 2016

Assignment 7

Issued: October 25, 2015

Due: November 1, 2015

Note: Excel file for Problems 1, 3, 5, 7, 8, 9 and 12 can be found in D2L. Use R for computations in the following questions and include the R code in your solution sheet.

Problem 1

Two machines are used for filling plastic bottles with a net volume of 16.0 ounces. The fill volume can be assumed normal, with standard deviation $\sigma_1 = 0.020$ and $\sigma_2 = 0.025$ ounces. A member of the quality engineering staff suspects that both machines fill to the same mean net volume, whether or not this volume is 16.0 ounces. A random sample of 10 bottles is taken 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) Do you think the engineer is correct? Use $\alpha = 0.05$.
- (b) What is the P-value for this test?
- (c) What is the power of the test in part (a) for a true difference in means of 0.04?
- (d) Find a 95% confidence interval on the difference in means. Provide a practical interpretation of this interval.
- (e) Assuming equal sample sizes, what sample size should be used to assure that $\beta = 0.05$ if the true difference in means is 0.04? Assume that $\alpha = 0.05$.

Problem 2

Two machines are used to fill plastic bottles with dishwashing detergent. The standard deviations of fill volume are known to be $\sigma_1 = 0.10$ fluid ounces and $\sigma_2 = 0.15$ fluid ounces for the two machines, respectively. Two random samples of $n_1 = 12$ bottles from machine 1 and $n_2 = 10$ bottles from machine 2 are selected, and the sample mean fill volumes are $\bar{x}_1 = 30.87$ fluid ounces and $\bar{x}_2 = 30.68$ fluid ounces. Assume normality.

- (a) Construct a 90% two-sided confidence interval on the mean difference in fill volume. Interpret this interval.
- (b) Construct a 95% two-sided confidence interval on the mean difference in fill volume. Compare and comment on the width of this interval to the width of the interval in part (a).
- (c) Construct a 95% upper-confidence interval on the mean difference in fill volume. Interpret this interval.
- (d) Test the hypothesis that both machines fill to the same mean volume. Use $\alpha = 0.05$.
- (e) What is the P-value of the test in part (d)?
- (f) If the β -error of the test when the true difference in fill volume is 0.2 fluid ounces should not exceed 0.1, what sample sizes must be used? Use $\alpha = 0.05$.

Problem 3

A polymer is manufactured in a batch chemical process. Viscosity measurements are normally made on each batch, and long experience with the process has indicated that the variability in the process is fairly stable with $\sigma = 20$. Fifteen batch viscosity measurements are given as follows: 724, 718, 776, 760, 745, 759, 795, 756, 742, 740, 761, 749, 739, 747, 742. A process change is made which involves switching the type of catalyst used in the process. Following the process change, eight batch viscosity measurements are taken: 735, 775, 729, 755, 783, 760, 738, 780. Assume that process variability is unaffected by the catalyst change.

- (a) Find a 90% confidence interval on the difference in mean batch viscosity resulting from the process change.
If the difference in mean batch viscosity is 10 or less, the manufacturer would like to detect it with a high probability.
- (b) Formulate and test an appropriate hypothesis using $\alpha = 0.10$. What are your conclusions?
- (c) Calculate the P-value for this test.
- (d) Compare the results of parts (b) and (c) to the length of the 90% confidence interval obtained in part (a) and discuss your findings.

Problem 4

Two catalysts may be used in a batch chemical process. Twelve batches were prepared using catalyst 1, resulting in an average yield of 86 and a sample standard deviation of 3. Fifteen batches were prepared using catalyst 2, and they resulted in an average yield of 89 with a standard deviation of 2. Assume that yield measurements are approximately normally distributed with the same standard deviation.

- (a) Is there evidence to support a claim that catalyst 2 produces a higher mean yield than catalyst 1? Use $\alpha = 0.01$.
- (b) Find a 95% confidence interval on the difference in mean yields.

Problem 5

The deflection temperature under load for two different types of plastic pipe is being investigated. Two random samples of 15 pipe specimens are tested, and the deflection temperatures observed are as follows (in $^{\circ}\text{F}$):

Type 1: 206, 188, 205, 187, 194, 193, 207, 185, 189, 213, 192, 210, 194, 178, 205.

Type 2: 177, 197, 206, 201, 180, 176, 185, 200, 197, 192, 198, 188, 189, 203, 192.

- (a) Construct box plots and normal probability plots for the two samples. Do these plots provide support of the assumptions of normality and equal variances? Write a practical interpretation for these plots.
- (b) Compare two variance using an F test.
- (c) Do the data support the claim that the deflection temperature under load for type 2 pipe exceeds that of type 1? In reaching your conclusions, use $\alpha = 0.05$.
- (d) Calculate a P-value for the test in part (c).
- (e) Suppose that if the mean deflection temperature for type 2 pipe exceeds that of type 1 by as much as 5°F , it is important to detect this difference with probability at least 0.90. Is the choice of $n_1 = n_2 = 15$ in part (a) of this problem adequate?

Problem 6

Two suppliers manufacture a plastic gear used in a laser printer. The impact strength of these gears measured in foot-pounds is an important characteristic. A random sample of 10 gears from supplier 1 results in $\bar{x}_1 = 290$ and $s_1 = 12$, while another random sample of 16 gears from the second supplier results in $\bar{x}_2 = 321$ and $s_2 = 22$.

- (a) Is there evidence to support the claim that supplier 2 provides gears with higher mean impact strength? Use $\alpha = 0.05$, and assume that both populations are normally distributed but the variances are not equal.
- (b) What is the P-value for this test?
- (c) Do the data support the claim that the mean impact strength of gears from supplier 2 is at least 25 foot-pounds higher than that of supplier 1? Make the same assumptions as in part (a).
- (d) Statistically verify the assumption that the variances are not equal.

Problem 7

The “spring-like effect” in a golf club could be determined by measuring the coefficient of restitution (the ratio of the outbound velocity to the inbound velocity of a golf ball fired at the clubhead). Twelve randomly selected drivers produced by two clubmakers are tested and the coefficient of restitution measured. The data follow:

Club 1: 0.8406, 0.8104, 0.8234, 0.8198, 0.8235, 0.8562, 0.8123, 0.7976, 0.8184, 0.8265, 0.7773, 0.7871

Club 2: 0.8305, 0.7905, 0.8352, 0.8380, 0.8145, 0.8465, 0.8244, 0.8014, 0.8309, 0.8405, 0.8256, 0.8476

- Is there evidence that coefficient of restitution is approximately normally distributed? Is an assumption of equal variances justified?
- Test the hypothesis that both brands of ball have equal mean coefficient of restitution. Use $\alpha = 0.05$.
- What is the P-value of the test statistic in part (b)?
- What is the power of the statistical test in part (b) to detect a true difference in mean coefficient of restitution of 0.2?
- What sample size would be required to detect a true difference in mean coefficient of restitution of 0.1 with power of approximately 0.8?
- Construct a 95% two-sided CI on the mean difference in coefficient of restitution between the two brands of golf clubs.

Problem 8

A computer scientist is investigating the usefulness of two different design languages in improving programming tasks. Twelve expert programmers, familiar with both languages, are asked to code a standard function in both languages, and the time (in minutes) is recorded. The data follow:

Programmer	Time	
	Design Language 1	Design Language 2
1	17	18
2	16	14
3	21	19
4	14	11
5	18	23
6	24	21
7	16	10
8	14	13
9	21	19
10	23	24
11	13	15
12	18	20

- (a) Find a 95% confidence interval on the difference in mean coding times. Is there any indication that one design language is preferable?
- (b) Is the assumption that the difference in coding time is normally distributed reasonable? Show evidence to support your answer.

Problem 9

Ten individuals have participated in a diet-modification program to stimulate weight loss. Their weight both before and after participation in the program is shown in the following list. Is there evidence to support the claim that this particular diet-modification program is effective in producing a mean weight reduction? Use $\alpha = 0.05$.

Subject	Before	After
1	195	187
2	213	195
3	247	221
4	201	190
5	187	175
6	210	197
7	215	199
8	246	221
9	294	278
10	310	285

Problem 10

A study was performed to determine whether men and women differ in their repeatability in assembling components on printed circuit boards. Random samples of 25 men and 21 women were selected, and each subject assembled the units. The two sample standard deviations of assembly time were $s_{\text{men}} = 0.98$ minutes and $s_{\text{women}} = 1.02$ minutes. Is there evidence to support the claim that men and women differ in repeatability for this assembly task? Use $\alpha = 0.02$ and state any necessary assumptions about the underlying distribution of the data.

Problem 11

Two different types of polishing solution are being evaluated for possible use in a tumble-polish operation for manufacturing interocular lenses used in the human eye following cataract surgery. Three hundred lenses were tumble-polished using the first polishing solution, and of this number 253 had no polishing-induced defects. Another 300 lenses were tumble-polished using the second polishing solution, and 196 lenses were satisfactory upon completion. Is there any reason to believe that the two polishing solutions differ? Use $\alpha = 0.01$. Discuss how this question could be answered with a confidence interval on $p_1 - p_2$.

Problem 12

A procurement specialist has purchased 25 resistors from vendor 1 and 35 resistors from vendor 2. Each resistors resistance is measured with the following results:

Vendor 1					
96.8	100.0	100.3	98.5	98.3	98.2
99.6	99.4	99.9	101.1	103.7	97.7
99.7	101.1	97.7	98.6	101.9	101.0
99.4	99.8	99.1	99.6	101.2	98.2
98.6					
Vendor 2					
106.8	106.8	104.7	104.7	108.0	102.2
103.2	103.7	106.8	105.1	104.0	106.2
102.6	100.3	104.0	107.0	104.3	105.8
104.0	106.3	102.2	102.8	104.2	103.4
104.6	103.5	106.3	109.2	107.2	105.4
106.4	106.8	104.1	107.1	107.7	

- (a) What distributional assumption is needed to test the claim that the variance of resistance of product from vendor 1 is not significantly different from the variance of resistance of product from vendor 2? Perform a graphical procedure to check this assumption.
- (b) Perform an appropriate statistical hypothesis-testing procedure to determine whether the procurement specialist can claim that the variance of resistance of product from vendor 1 is significantly different from the variance of resistance of product from vendor 2.