KEY

ECHE 313 Test 1

Write your name:

The exam layout is such that all problems add up to 100 points. This point total is meant to guide you in time allocation for this test and will be adjusted such that this exam is 25% of your total class grade. You may use class materials, class notes, formula sheet, homework, book, and calculator (with no internet access) to aid in the completion of the exam. The exam is designed to be completed in 1hr and 15 min. All of the necessary tables are provided in the back of your book. Please show your work and all steps necessary to arrive at your answer. Where applicable, it is best to write out the general formals you want to use first, then write in your subbed in values so it is clear. In addition, for this exam, we can use the rule of thumb that if the sample variance ratio (larger to smaller) is lower than 4, you can assume equal variance for a t-test (if needed). Remember to specify what kind of t-test you are doing if you choose a t-test. Also, when reporting numbers, keep the same number of decimals as the data you are working with unless there are specific directions on how many sig figs to report.

Good luck!

Premise: You are a process engineer working for a company that makes fabric for the textile industry and wants to start implementing lean and six sigma practices. Unless otherwise stated, your company uses α=0.01.

1) (7 points) Choose from the following word bank for each of the situations below. Terms can be used more than once or may not be used at all.

Define Stage Measure Stage Analyze Stage Improve Stage Control Stage Tollgate Review

Lean Manufacturing Sigma Performance Level

a. Your team is tasked with understanding the current variability in a process. You are in the Measure Stage
b. Your team wishes to investigate if mistake proofing and better flow in the assembly area increase process cycle efficiency. These approaches are examples of Lean Manufacturing
c. Your team is using hypothesis testing to determine if changing the temperature has a significant effect on a critical to quality characteristic. You are in the Analyze Stage
d. Your team is meeting today to ensure that your project is on track or otherwise known as Tollgate Review
e. You and your team are drafting a project charter after using a Pareto chart to identify the best value opportunity. You are in the Define Stage
f. Your team is determining the causes of sources of variation in a process. You are in the Analyze Stage
g. Your team is drafting up documentation outlining an alternative processing method that has a significant desired effect on the process. You are in the Control Stage

will also accept improve (but drafting docs at the end is control!)

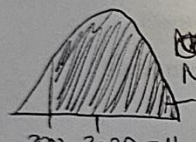
2) (10 points) Deem the following statements as True or False by circling either T or F:

F T T F T F F F T T

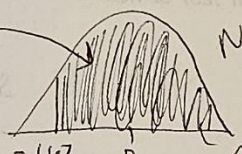
a. Quality assurance involves listening to the voice of the customer for what they say is most important and translating that into something measurable: T or (F)
b. Part of a quality engineer's job is to deal with the "hidden factory": (T) or F
c. Six Sigma is a management approach (T) or F
d. Generally, external and internal failure costs are preferable to prevention costs: T or (F)
e. Quality is related to variability: (T) or F
f. The lower the sigma level, the less likely it is there will be a defective part: T or (F)
g. Specification limits indicate how variable your process is: T or (F)
h. The slower the process is, the higher product quality and profit: T or (F)
i. Lean manufacturing is a process management strategy that reduces waste, with a special emphasis on time: (T) or F
j. DMAIC is a problem solving method used in Six Sigma: (T) or F

3) (13 points) For one of the fabrics your company makes, it is known that the mean tensile strength is normally distributed with a mean (μ) of 3000 psi and a standard deviation (σ) of 300 psi.

a. (4 points) Your team has learned through surveys that it is really important to the customer that the tensile strength is above 2000 psi. What is the probability that the fabric coming off of your manufacturing line is above 2500 psi? (report 2 sig figs)



$N(3000, 300^2)$ $P(x > 2500) = ? \Rightarrow$



$z = \frac{x-\mu}{\sigma} = \frac{2500-3000}{300}$

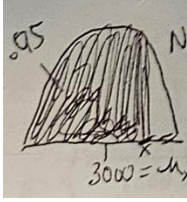
$P(x > 2500psi) = 0.95$ $P(z > 1.67) = .95$ $= -1.67$

b. (4 points) Assuming your specifications are for material to be between 2500 (LSL) and 3500 (USL) psi tensile strength, and your target is 3000 psi, is this process better or worse (has higher variability or lower variability) than a 6 sigma level process?

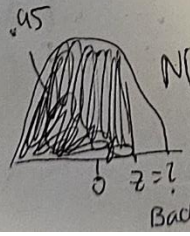
$\frac{|\text{spec. limit} - \text{target}|}{\sigma} = \text{sigma level} = \frac{500}{300} = 1.7$ This is not 6σ level (more variable)

c. (5 points) You take a sample of n=25 fabric swatches and find the sample mean. You have figured out that 95% of sample averages are below sample mean you just calculated. What is the sample mean value? (report 3 sig. figs)

Sampling Dist.



$N(3000, \frac{300^2}{25})$ $\Rightarrow$



$z = \frac{\bar{x} - \mu}{\frac{\sigma}{\sqrt{n}}}$ $\bar{x} = z\left(\frac{\sigma}{\sqrt{n}}\right) + \mu$

Back of book: $z = 1.65$ $\bar{x} = 1.65\left(\frac{300}{\sqrt{25}}\right) + 3000$

$\bar{x} = 3100$ psi

4) (4 Points) List the name of the statistical test that should be performed for each scenario below using the following word bank (words can be used more than once or not at all). Assume normal distributions for all data.

Bank: One-sample Z-test, two-sample Z-test, one-sample t-test, two-sample t-test (equal variance), two-sample t-test (unequal variance), paired t-test

a. Two machines are used for pressing fabric. A random sample of fabric from machine 1 and from machine 2 results in average of $\bar{x}_1 = 2.04$ mm, $\bar{x}_2 = 2.07$ mm with $s_1 = 0.10$ and $s_2 = 0.10$. We wish to test the hypothesis that that both machines press fabric to the same thickness.

Name of the test: two-sample t-test, equal variance

b. Sixteen observations of fiber impurities were taken in a sample: 10.35, 9.30, 10.00, 9.96, 11.65, 12.00, 11.25, 9.58, 11.54, 9.95, 10.28, 8.37, 10.44, 9.25, 9.38, and 10.85. We wish to test the hypothesis that the mean impurity level is 12 ppm.

Name of the test: one-sample t-test

c. One process which produces fibers is known to have a standard deviation of $\sigma = 0.0002$ mm fiber diameter. A random sample of 15 fibers is taken with an average diameter of 0.2563 mm and standard deviation of 0.0025 mm^2. We wish to test the hypothesis that the mean diameter is 0.2600 cm.

Name of the test: one-sample z-test

d. The thickness of the same fabric sample is measured by 12 inspectors, each using both a micrometer caliper and a vernier caliper. The results are shown in the table to the right. We wish to test if there a difference between the mean measurements produced by the two types of caliper.

Inspector	Micrometer Caliper	Vernier Caliper
1	0.150	0.151
2	0.151	0.150
3	0.151	0.151
4	0.152	0.150
5	0.151	0.151
6	0.150	0.151
7	0.151	0.153
8	0.153	0.155
9	0.152	0.154
10	0.151	0.151
11	0.151	0.150
12	0.151	0.152

Name of the test: paired t-test

5) (33 points) Your team has listened to the voice of the customer with surveys, and it is clear that textiles releasing less microplastics is desirable. So, the team used new fibers in the process in the hope that it lowers the release of microplastics when washed. Seven fabric samples were taken from the process with the old fibers, and ten samples were taken from the process with the new fibers. The samples were washed and the number particles released (particles/gram of material) was measured for each sample. Your team's process for creating textiles is very well-characterized, so much so that *the variance is known* to be 200,000 (particles/gram)^2, and your team knows that there is the same variance for these new fibers. Your boss wants to know, is there a difference in the particles released in the new process? The data table is below with some calculations already performed.

Sample #	**Old Fibers (1)**	**New Fibers (2)**
1	3,501	2098
2	2877	1504
3	2432	1741
4	3645	1805
5	2987	2146
6	2637	873
7	3671	1606
8		1259
9		781
10		1874
Sample Average	3,107	1,682
Sample Standard Deviation	501	428

*note, data is given in particles/gram of material

a. (3 points) List the parameter you are interested in and the *name* of the hypothesis test you would use

Parameter of interest: difference in means of "old" and "new" fiber #
Test: 2-sample Z-test (variance is known)

b. (2 points) Write out the correct null hypothesis for this test

$H_0: \mu_{old} - \mu_{new} = 0$

c. (3 points) Write out the correct alternative hypothesis for this test

$H_1: \mu_{old} - \mu_{new} \neq 0$

d. (6 points) Write the formula of the test statistic and calculate (report 3 sig figs)

$$z_0 = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}} = \frac{3107 - 1682}{\sqrt{\frac{200000}{7} + \frac{200000}{10}}} = \boxed{6.47}$$

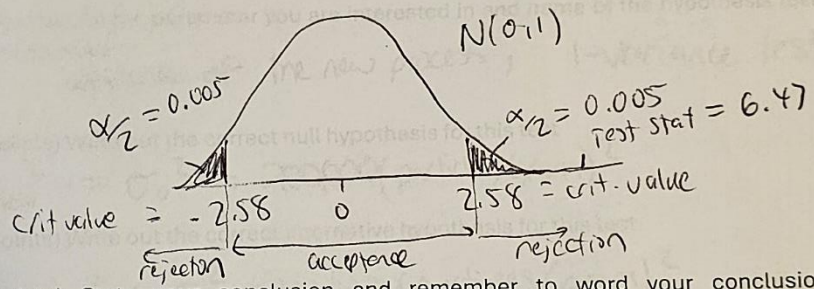
e. (3 points) Write out the correct rejection criteria using the fixed significance-level method (report your values to 3 sig. figs.)

Reject if $z_0 > z_{\alpha/2}$ or if $z_0 < -z_{\alpha/2}$

Reject if $z_0 > 2.58$ or if $z_0 < -2.58$

$z_{\alpha/2} = z_{.005} \rightarrow .995$ on chart $\Rightarrow 2.58$

f. (10 points) Sketch out your reference distribution making sure to fully define the distribution you are sketching on with the correct label, drawing it with the correct shape and where zero is. In addition, label 1) acceptance region, 2) the rejection region (also known as the critical region), 3) α, 4) the critical value(s) and 5) the test statistic.



g. (4 points) State your conclusion and remember to word your conclusion appropriately in the context of the problem statement. ALSO state what would you recommend to your boss (should she consider using the new fibers?)

Reject H_0 and accept H_1. The new fibers release a different (lower) amount of microplastics than the old. The boss should consider using the new fibers.

h. (2 points) Name the hypothesis test would you do if you did not know the variance of the process? (be specific)

two-sample t-test, equal variance

6) (33 points) Your team decides that the variance in the release of microparticles in process for making material is too high. Some adjustments are made, and 10 samples are taken from the new manufacturing process with the adjustments. The data with some calculations are given below. Your boss wants to know, is the variance of this new process less than 200,000 (particles/gram)^2?

Sample #	New Process
1	3,456
2	2479
3	2697
4	3597
5	3002
6	2549
7	3596
8	2874
9	2768
10	2972
Sample Average	2,999
Sample Standard Deviation	416

*note, data is given in particles/gram of material

a. (3 points) List the parameter you are interested in and *name* of the hypothesis test you would use

variance of the new process, 1-variance test

b. (2 points) Write out the correct null hypothesis for this test

$\sigma_{new}^2 = \sigma_0^2 = 200{,}000 (particles/gram)^2$

c. (3 points) Write out the correct alternative hypothesis for this test

$\sigma_{new}^2 < \sigma_0^2 = 200{,}000 (particles/gram)^2$

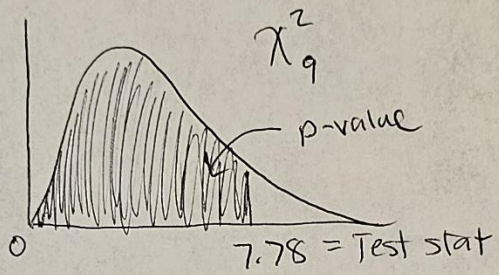
d. (6 points) Write the formula of the test statistic and calculate its value (report 3 sig. figs.)

$\chi_0^2 = \frac{(n-1)S^2}{\sigma_0^2} = \frac{9(416)^2}{200{,}000} = \boxed{7.78}$

e. (2 points) Define your general rejection criteria using the p-value method

Reject if p-value $< \alpha = 0.01$

f. (7 points) Sketch out your reference distribution making sure to fully define the distribution you are sketching on with the correct label, drawing it with the correct shape and where zero is. In addition, label 1) the test statistic and 2) the p-value.



g. (3 points) Find the p-value range using the tables in the back of your book

1 - area in back of book

$1 - 0.950 = 0.05$

$1 - 0.5 = .5$

$0.05 < p\text{-value} < 0.5$

h. (3 points) State your conclusion and remember to word your conclusion appropriately in the context of the problem statement.

Fail to reject H_0. We don't have enough evidence to say that the variance of the new process is lower than $200{,}000\ (\text{particles}/g)^2$

i. (4 points) Generally explain what a reference distribution is and when your test statistic is in the critical region why we can reject the null hypothesis.

A reference dist. is the dist. the test statistic takes when the null is true. If a value falls in an area not many test stats would be if the null were true, this helps us conclude H_0 is not likely to be true (with a specific degree of error, α)