ECHE 313 Final Exam (practice)

Name:

Same format as before – 24 hours to complete the exam. You will sign and ethics statement. It is open note, open book, and you can use Excel/Minitab but you must do the problem by hand and show enough work to prove you can do the problem by hand. Hope this practice exam is helpful!

1) **(8 points total) Describe the following:**
    a. (4 points) Three distinct ways extra variability in a process can lead to higher cost.

    b. (4 points) At least three distinct reasons slow processes are expensive processes.

2) **(10 Points) List the name of the statistical test that should be performed for each scenario below using the following word bank (names can be used more than once). 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, 1 variance test, 2 variance test

a. (2 points) Two machines are used for filling glass bottles with a soft-drink beverage. The filling processes have known standard deviations of $\sigma_1 = 0.010$ and $\sigma_2 = 0.015$, respectively. A random sample of bottles from machine 1 and bottles from machine 2 results in average net contents of $\overline{x}_1 = 2.04$, $\overline{x}_2 = 2.07$. We wish to test the hypothesis that that both machines fill to the same net contents.

Name of the test:

b. (2 points) The inside diameters of bearings used in an aircraft landing gear assembly are known to have a standard deviation of $\sigma = 0.0002$ cm. A random sample of 15 bearings has an average inside diameter of 8.2535 cm. We wish to test the hypothesis that the mean inside bearing diameter is 8.25 cm.

Name of the test:

c. (2 points) The diameter of a metal rod 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:

d. (2 points) Sixteen observations of output voltage for a power supply are taken at random: 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 voltage is 12 V.

Name of the test:

e. (2 points) Sixteen observations of output voltage for a power supply are taken at random: 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 $\sigma^2 = 11$.

Name of the test:

3) **(10 points) The time that your phone battery lasts under typical conditions is normally distributed with parameters μ = 9.5 hours and σ = 0.8 hours. What is the probability that your battery lasts more than 10 hours?**

   a. (5 points) Write out the probability equation for this problem (no need to normalize), and sketch out the problem using a normal probability sketch (label x=10, μ = 9.5, σ = 0.8 and P, the probability)

Probability equation: Sketch:

   b. (5 points) Convert the probability equation written in part (a) to a probability equation that can be solved using the standard normal distribution, and solve.

Show your work to convert equation and solve using the standard normal distribution

Write final answer: what is the probability that your phone battery lasts more than 10 hours (use two significant figures)?

4) **(25 points) 11 operators on a manufacturing line have taken an online training module on lean manufacturing. The difference between the time taken to complete a task before the module and after the model (time before module – time after module) for the 11 operators was $\bar{x}$ = 15.45 min, and the standard deviation was σ = 14.40 min. You wish to know if there is enough evidence that the difference in time is non-zero at an alpha level = 0.05. You consider it possible that the video could increase or decrease the time to do a task. Keep 2 significant figures in this problem (average and standard deviation are shown with more significant figures for ease of calculations).**

Operator	t1 (min)	t2 (min)	Difference in Process Time (t1 - t2)
1	60	50	10
2	80	50	30
3	80	50	30
4	90	50	40
5	100	100	0
6	90	90	0
7	80	70	10
8	80	70	10
9	100	70	30
10	90	80	10
11	80	80	0

$\bar{x}$ = 15.45

σ = 14.40

a) (2 point) Name the correct statistical test to conduct (use the word bank in in problem 2)

Name of test:

b) (4 points) Write the correct null and alternative hypotheses:

Null hypothesis:

Alternative hypothesis:

c) (5 points) Calculate the test statistic (keep two significant figures for the final answer)

Write out the general formula: Sub in values and calculate:

d) (4 points) Write out the correct rejection criteria and the critical value that you will compare the test statistic to (keep two significant figures for the final answer)

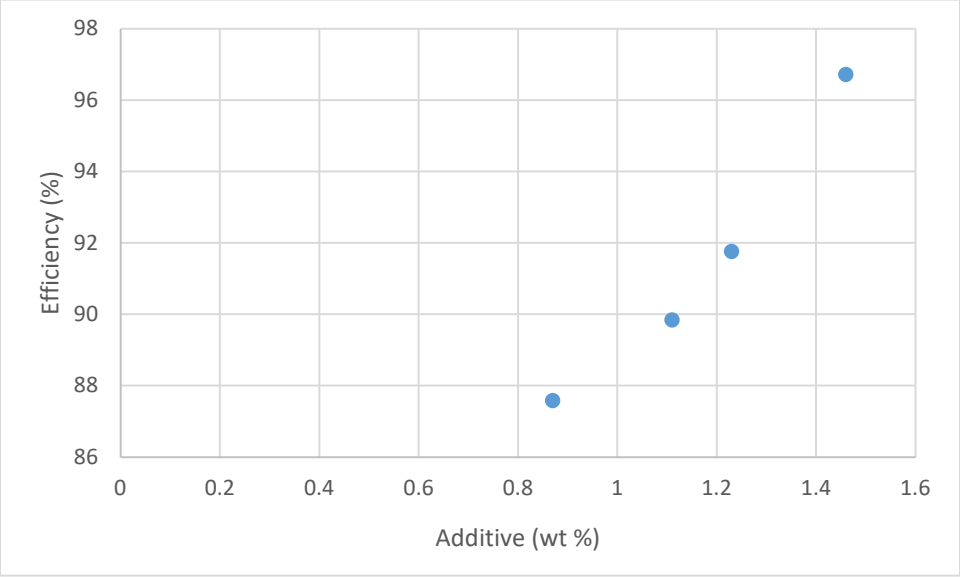
Rejection criteria: Critical value:

e) (8 points) Sketch out the reference distribution for this problem and label: the type of reference distribution used and any defining characteristics, the critical values, the test statistic, alpha, the acceptance region and the rejection region.

f) (2 points) Write your conclusions and comment on if you think the change in operator time to do a task is non-zero after watching the training video, and if you would recommend this video for the future.

5) **(35 points) You work for an electrode company and are investigating an ink additive. You obtain the following data by controlling the wt % of the ink additive and the measuring the ultimate performance (efficiency, %) of the resulting electrode. You wish to fit a simple linear regression model to this data, and determine if it is significant using ANOVA. You have already performed least squares regression to find that the slope (B1) is 15.47, and the intercept is (B0) is 73.42. Keep 3 significant figures in your answers.**

Wt% Additive (x)	Efficiency % (y)
0.87	87.59
1.46	96.73
1.11	89.85
1.23	91.77



a) (6 points) Calculate the sum of squares total (SST) for this data set

Write out the SST general formula(s) for linear regression:

Sub in values into your formula(s) and calculate SST:

b) (8 points) Calculate the sum of squares regression (SSR) for this data set

Write out the formula(s) needed to calculate SSR for linear regression:

Sub in values into your formula(s) and calculate SSR:

c) (4 points) Calculate SSE

Write out the formula(s) needed to calculate SSE for linear regression:

Sub in values into your formulas and calculate SSE:

d) (4 points) Write out the null and alternative hypothesis needed to test if the linear model is significant using ANOVA.

e) (9 points) Calculate the test statistic needed to test your hypothesis with ANOVA, and explain generally how the test statistic relates to the reference distribution, as well as what the test statistic itself (F0) generally represents.

Write out the formula needed to calculate the test statistic (general):

Sub in values into your formula and calculate the test statistic:

How are the test statistic and the reference distribution related?

What, generally does Fo represent (what is it really comparing as far as the variance?)

f) (4 points) Based on your test statistic, find the p-value range – you can use your calculator to get a single value if you wish, and, explain what the p-value represents

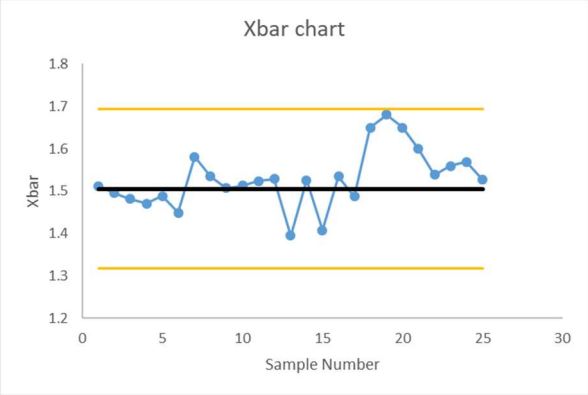
P-value:

What does the p-value represent?

6) **(11 points total) For the control chart below (showing 3σ control limit lines in yellow):**
a) (5 points) Use the criteria to determine if the process below is in control. State what, if any, rules have been violated.

Some Sensitizing Rules for Shewhart Control Charts

Standard Action Signal:	**1.** One or more points outside of the control limits	
	2. Two of three consecutive points outside the two-sigma warning limits but still inside the control limits	Western Electric Rules
	3. Four of five consecutive points beyond the one-sigma limits	Western Electric Rules
	4. A run of eight consecutive points on one side of the center line	Western Electric Rules
	5. Six points in a row steadily increasing or decreasing	
	6. Fifteen points in a row in zone C (both above and below the center line)	
	7. Fourteen points in a row alternating up and down	
	8. Eight points in a row on both sides of the center line with none in zone C	
	9. An unusual or nonrandom pattern in the data	



Is the process in control?

What, if any, rules have been violated?

b) (6 points) Explain what impact wide or narrow control limits have on type I and type II error, define type I and type II error as they pertain to control charts

Define type I and type II error:

What impact does wide or narrow control limits have on type I and type II error?

7) (45 points) Consider a 2^2 factorial experiment with four center points. The data are (1) = 21, a = 125, b = 154, ab = 352, and the responses at the center point are 168, 130, 162, 125. Use three significant figures in your final answers, and use alpha=0.05.

a. (5 points) Fill out the table below using coded values of -1 for lowest setting, and 1 for highest parameter setting for each run below.

	A	B	AB	Response
(1)				
a				
b				
ab				
Center point 1				
Center point 2				
Center point 3				
Center point 4				

b. (10 points) Test for curvature only using pure error since the lowest ordered term here is a potentially significant two-way interaction. Write out all general formulas needed, sub in the correct values to calculate, and write out your conclusions.

c. (12 point) Test if Factor A is significant by using ANOVA and a value of 499.5 for MSE (which will have 4 degrees of freedom). Note that this MSE was obtained by pooling error from the pure quadratic (since it wasn't significant it can be counted as error). Write out all general formulas needed, sub in correct values to calculate, and state your conclusion.

d. (6 points) Let's say you perform the same analysis as in part c) for factor B and interaction AB and get a p-value of 0.001 and 0.103 for factor B and interaction AB respectively. You also calculate the coefficients of B and AB to be 90.0 and 23.5 respectively. Combined with your analysis in part c) write out a prediction model and calculate the predicted response at the highest level of A and the midpoint of B.

e) (5 points) Sketch out the main effect plot for A

f) (7 points) Sketch out the interaction plot for AB and comment on if it agrees with the result of AB not being significant (what is it about the shape that supports AB not being significant?)

8) **(6 points) Describe when fractional factorials might be useful, what is aliasing, and why aliasing may or may not be problematic**

Bonus (1 point): List at least one advantage of Design of Experiments