STATISTICS 641 - ASSIGNMENT 8

DUE DATE: NOON, WEDNESDAY, DECEMBER 8, 2021

Name ____

Email Address ____

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STATISTICS 641 - ASSIGNMENT 8

- **Due Noon Wednesday, December 8, 2021**
- Read Handout 13
- Supplemental Reading from Devore book: Chapters 9, 10, 14, & 15

(P1) (8 points) In each of the following studies, state whether the study uses an independent samples or a matched pairs design:

(S1) In an evaluation of the efficiency of algorithms, two algorithms are evaluated in terms of CPU times required to complete the same six test problems.

(S2) A survey is conducted of 16 year old students from inner city public schools and suburban public schools to compare the proportion who had experimented with marijuana.

(S3) A psychologist designs a study to assess whether a visual or audio stimulus produces a more rapid response. A group of 250 undergraduates are randomly assigned to the order in which they are exposed to the two stimuli, audio then visual or vice versa. The response times to the stimuli are then recorded.

(S4) The effect of two types of viruses on tobacco leaves was studied by rubbing a preparation containing one of the viruses onto a different half of each of 8 tobacco leavers. The number of lesions counted on the two halves of these leavers were recorded.

(P2) (8 points) An experiment is run to study the effects of PCB, an industrial contaminant, on the reproductive ability of owls. The shell thickness (mm) of eggs produced by 10 owls exposed to PCB are compared to the shell thickness of eggs produced by 10 owls which did not have PCB exposures.

Owl	1	2	3	4	5	6	7	8	9	10
PCB-Exposed:	3.6	3.2	3.8	3.6	4.1	3.8	4.2	3.4	3.7	3.8
UnExposed:	4.3	4.4	3.6	3.5	4.4	3.5	3.4	3.6	4.1	4.3

1. Is there significant($\alpha = .05$) evidence that the PCB exposed owls have thinner egg shells than those of the unexposed owls? Use a t-test in reaching your conclusion and report the p-value.
2. Compute the chance that your test committed a Type II error for the following values of $\theta = \mu_{exposed} - \mu_{unexposed} = 0, -.5\sigma, -\sigma, -1.5\sigma, -2\sigma$.
3. In designing a new study, the researchers want to determine the necessary sample sizes for exposed and unexposed owls such that an $\alpha = .05$ test will have power of at least 80% to detect a shell thickness difference of more than 0.3 mm. The researchers want to examine three times as many exposed owls as unexposed owls, that is, m=3n.
4. Is there significant($\alpha = .05$) evidence that the PCB exposed owls have thinner egg shells than those of the unexposed owls? Use a Wilcoxon test in reaching your conclusion and report the p-value.
5. Is there significant($\alpha = .05$) evidence that the PCB exposed owls have greater variability in egg shell thickness than those of the unexposed owls? Report the p-value of your test.
6. Which test, t-test or Wilcoxon, is more appropriate for testing the difference in egg shell thickness?

(P3) (8 points) In a study of the effect of vitamin B on learning, 12 pairs of children were matched on IQ, age, size, and general health. Within each pair, one child was randomly selected to receive a vitamin B table every day and the other child received a placebo tablet. The following table shows the change in IQ score over the six months of the study.

Pair	1	2	3	4	5	6	7	8	9	10	11	12
Vitamin B	14	26	2	4	-5	14	3	-1	1	6	3	4
Placebo	8	18	-7	-1	2	9	0	-4	13	3	3	3

Is there substantial evidence that a six months treatment with vitamin B increased IQ score? Use $\alpha = .05$ in applying both the t-test and the Wilcoxon signed rank test for these hypotheses. Which test produces the most reliable conclusion?

(P4) (8 points) A study evaluated the urinary-thromboglobulin excretion in 12 normal and 12 diabetic patients. The excretions were summarized with a value of 20 or less labeled as "Low" and values above 20 as "High".

	Excretion	
	Low	High
Normal	10	2
Diabetic	4	8

1. Set up hypotheses to assess whether there is substantial evidence of a difference in the urinary-thromboglobulin excretion between normal and diabetic patients.
2. At the $\alpha = .05$ level what can you conclude? Report a p-value for your test.

(P5) (8 points) A study was conducted to compare two topical anesthetic drugs for use in dentistry. The two drugs were applied on the oral mucous membrane of the two sides of each patient's mouth and after a fixed period of time it was recorded whether or not the membrane remained anesthetized. Data from the 45 patients is recorded below:

		Drug 2 Response	
		Anesthetized	Not Anesthetized
Drug 1	Anesthetized	15	13
Response	Not Anesthetized	3	14

1. Set up hypotheses to assess whether there is substantial evidence of a difference between the two drugs.
2. At the $\alpha = .05$ level what can you conclude? Report a p-value for your test.

(P6) (8 points) A genetics experiment on the characteristics of tomato plants provided the following data on the number of offspring expression four phenotypes.

Phenotype	Tall, cut-leaf	Dwarf, cut-leaf	Tall, potato-leaf	Dwarf, potato-leaf	Total
Frequency	926	293	288	104	1611

The researcher wants to determine if there is substantial evidence that the tomato plants deviate from the current theory that the four phenotypes will appear in the proportion 9:3:3:1. Use $\alpha = .01$.

(P7) (14 points) A company is attempting to automate the determination of the amount of the active ingredient, chlorphaniramine maleate, in the tablets it produces. Two labs were asked to make 20 determinations on a composite sample which had a nominal dosage level of 4 milligrams. The purpose of the experiment was to study the consistency between labs and the variability of the determination procedure within labs. The data is given in the following table.

	Day									
	1	2	3	4	5	6	7	8	9	10
Lab 1	4.13	4.07	4.04	4.07	4.05	4.04	4.02	4.06	4.10	3.86
Lab 2	3.88	4.02	4.01	4.01	4.04	3.99	4.03	3.97	3.98	4.02

	Day									
	11	12	13	14	15	16	17	18	19	20
Lab 1	3.85	4.08	4.11	4.08	4.01	4.02	4.04	3.97	4.00	4.04
Lab 2	3.88	3.91	3.95	3.92	3.97	3.92	3.90	3.89	3.97	3.95

1. Do the readings from the labs appear to have a normal distribution? Justify your answer.
2. Do the readings from the two labs appear to have the same level of variability? Justify your answer.
3. Do the daily determinations within each lab appear to be correlated? Justify your answer.
4. Do the readings from the two labs appear to have different average determinations? Justify your answer.
5. Provide 95% confidence intervals on the average determinations for both labs.

(P8) (8 points) A study was conducted to investigate whether there is a relationship between tonsil size and carriers of a particular bacterium, *Streptococcus pyrogenes*. The following table contains the results from 1398 children.

Tonsil	Carrier Status		Row
Size	Carrier	Noncarrier	Total
Normal	19	497	516
Large	29	560	589
Very Large	24	269	293
Column Total	72	1326	1398

Is there significant evidence that tonsil size and carrier status are associated? Use $\alpha = .05$.

(P9) (8 points) The following table gives the racial characteristics of 326 individuals convicted of homicide and whether or not they received the death penalty. Social scientists were interested in the relationship between Defendant's Race and the probability that the defendant would receive the Death Penalty. A possible confounding variable is the Race of the homicide victim

	Victim's Race			
	White		Black	
	Death Penalty		Death Penalty	
Defendant's Race	Yes	No	Yes	No
White	19	132	0	9
Black	11	52	6	97

1. Test whether there is significant evidence that frequency of receiving the Death Penalty is related to Defendant's Race ignoring the Victim's Race. Use $\alpha = .05$.
2. For each category of Victim's Race, test whether there is significant evidence that frequency of receiving the Death Penalty is related to Defendant's Race. Use $\alpha = .05$.
3. Test whether there is significant evidence that frequency of receiving the Death Penalty is related to Defendant's Race after adjusting for the Victim's Race. Use $\alpha = .05$.
4. Compare your three conclusions and comment on the differences.

(P10) (22 points) Multiple Choice Questions.

CIRCLE ONE of the following letters **(A, B, C, D, or E)** corresponding to the **BEST** answer.

Use the following information for MC1 and MC2.

A process engineer samples a continuous flow of the company's product 200 times per day and obtains the following pH levels in the product : $X_1, \cdots, X_{200}$. He determines that the daily pH levels are related by $X_t = \theta + \rho X_{t-1} + e_t$, where the e_ts have independent $N(0, \sigma_e^2)$ distributions and $\rho > .9$.

MC1 The engineer constructs a nominal 95% confidence interval for the average daily pH level, μ, using the formula $\bar{X} \pm t_{.025,199}(s/\sqrt{200})$, where $\bar{X}$ and s are the sample mean and standard deviation for a given days pH levels. The true coverage probability of this confidence interval

A. is 0.95.

B. is very close to 0.95.

C. is much less than 0.95.

D. is much greater than 0.95.

E. may be greater than 0.95 or less than 0.95 depending on the distribution of the X_t's.

MC2 Refer to MC1. The nominal pH level of the product is 5.3. The process engineer wants to test if the pH on a given day is different from 5.3. He uses $t = \frac{\bar{X}-5.3}{s/\sqrt{200}}$ as his test statistic. Next, he uses the t-distribution with df=199 to compute the p-value of the observed data. The computed p-value will be

A. correct because the sample size is large.

B. very close to the correct p-value because the sample size is large.

C. much larger than the correct p-value.

D. much smaller than the correct p-value.

E. may be greater or less than the correct value depending on the size of $sigma$.

MC3 A psychologist is investigating the IQ level of young children who have been in a head start program. She wants to determine if the variation in IQ scores for the population of head start students is smaller than the variation in the general population of children under the age of 6 which has a variation of $\sigma = 10.2$. She also informs you that the distribution of IQ scores is highly right skewed. Suppose she uses the test: reject H_o is $\frac{(n-1)S^2}{(10.2)^2} < \chi^2_{.95,n-1}$, where S is the standard deviation from a random sample of n head start students, to test whether σ is less than 10.2 with an α value of 0.05.

A. the actual level of significance will be very close to 0.05.

B. the actual level of significance will be less than 0.05.

C. the actual level of significance will be greater than 0.05.

D. the actual level of significance will be exactly 0.05.

E. it is impossible to determine the effect of skewness on the actual level of significance.

MC4 In testing $H_o : \mu \geq \mu_o$ versus $H_1 : \mu < \mu_o$, where μ is the mean of a population having a symmetric pdf, f,

A. the power of the t-test depends on the shape of f.

B. the power of the t-test is greater than the power of the sign test.

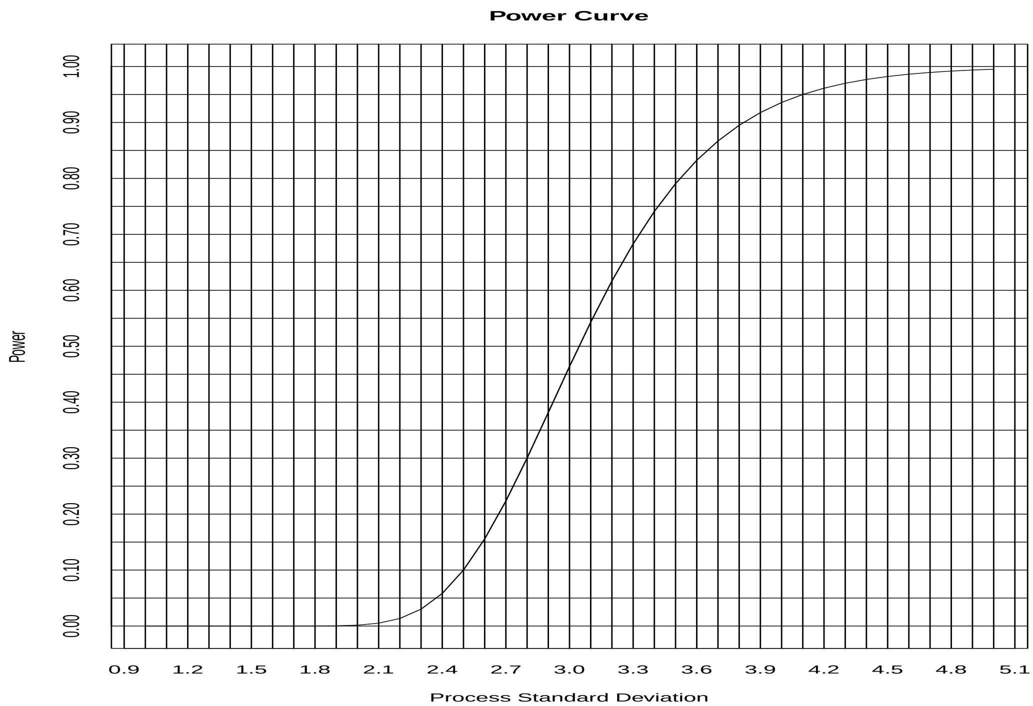
C. the power of the t-test is less than the power of the Wilcoxon signed-rank test.

D. the power of the t-test is less than the power of the sign test.

E. the power of the t-test is greater than the power of the Wilcoxon signed-rank test.

The following discussion will supply the information for Questions MC5, MC6, and MC7.

A company that manufacturers silicon wafers for computer chips is concerned with both the mean thickness of the chips and the fluctuation in the thickness of the chips. In order to monitor the thickness, a random sample of n chips is selected every hour and the thickness is measured on each of the chips. The process is considered to be in control provided the process mean, μ, is 200 mm and the process standard deviation, σ is less than or equal to 2.5 mm. The company's process engineer develops a test to evaluate whether the process standard deviation is greater than 2.5 mm. She plots the power curve of the test in order to evaluate its performance. The curve is given here:



MC5 What is the maximum probability of a Type I error when using the test whose power curve is depicted above?

A. .05

B. .10

C. .15

D. .90

E. .95

MC6 What is the probability of a Type II error of the test in MC5 if $\sigma = 3.5$?

A. .21

B. .31

C. .69

D. .79

E. cannot be determined from the power curve

MC7 Refer to MC5. The process engineer decides to reduce the size of the test to $\alpha = .01$ and use n=40 chips in the study. What is the probability of a Type II error using an $\alpha = .01$ test when $\sigma = 2.775$?

A. .29

B. .71

C. .90

D. .95

E. .99

MC8 A biologist designs a study to determine if the average wing span of Mexican bats is less than the average wing span of South Carolina bats which is know to be 3.0 mm. She wants to determine how many Mexican bats to include in the study so that the probability of a Type II test at $\mu = 2.8$ mm is at most 0.20 if she uses an α=.05 test. It is well known that the wing spans have a normal distribution. The biologist states she thinks that the wing span of Mexican bats have $\sigma \approx .4$ mm. The sample size must be at least

A. 16

B. 25

C. 35

D. 80

E. cannot be determined with the given information

MC9 A random sample of 70 units was taken from a population yielding values $Y_1, \ldots, Y_{70}$. From this data, the following confidence intervals for the population mean μ were computed: $\bar{Y} \pm t_{\alpha/2,69} S/\sqrt{70}$

90% $C.I.$ $(22.5, 26.5)$; 95% $C.I.$ $(22.1, 26.9)$; 99% $C.I.$ $(21.4, 27.6)$

In testing the hypotheses: $H_o : \mu \leq 21$ versus $H_1 : \mu > 21$, the $p - value$ computed from the data is

A. $p - value \leq .005$

B. $.005 < p - value \leq .01$

C. $.01 < p - value \leq .05$

D. $p - value > .05$

E. cannot be determined using confidence intervals

MC10 You have been assigned to design an experiment to compare the mean responses from a placebo treatment and a new drug. You can either randomly assign n experimental units to each of the treatments or you can pair the $2n$ experimental units based on severity of the disease and then randomly assign the two treatments within each pair of experimental units. Which of the following statements is **TRUE**?

A. Pairing results in a large increase in the power of the paired t-test provided there is negative correlation within the pairs.

B. Pairing results in a large increase in the power of the paired t-test provided there is positive correlation within the pairs.

C. Pairing will always increase the power of the t-test, at least to some degree.

D. Pairing is done to reduce the variance in the difference in the two sample means.

E. Pairing would reduce the power of the t-test if the 2n experimental units have nearly the same level of severity of the disease.

MC11 A biologist for a large pharmaceutical firm wants to determine the strength of a drug at various times after being injected into the patient. He injects the drug into 40 patient and then takes blood samples every 30 minutes for the next 10 hours yielding 20 strength values: $X_{1i}, \ldots, X_{20i}$ for each of the $i = 1, \ldots, 40$ patients. He uses the mean responses from the 40 patients, $\bar{X}_1, \ldots, \bar{X}_{40}$, to test the hypotheses $H_o : \mu \leq 53$ versus $H_1 : \mu > 53$, where μ is the average strength of the drug during the 10 hours. An evaluation of the data reveals the following:

- The normal reference distribution plot has many data values above the line on the right end of the graph and many data values below the line on the left end of the graph.
- The Shapiro-Wilk test has p-value=0.003.
- The 20 data values have a lag one autocorrelation value $\hat{\rho}_1 = 0.009$.

A test was constructed using the following decision rule: $\frac{\bar{\bar{X}}-53}{S/\sqrt{40}} \geq t_{.05,39}$, where $\bar{\bar{X}}$ and S are the mean and standard deviation of $\bar{X}_1, \ldots, \bar{X}_{40}$. The true level of significance of this test would be

A. 0.05.

B. very close to 0.05.

C. much less than 0.05.

D. much greater than 0.05.

E. may be greater or less than 0.05 depending on the value of σ.