Please put your name on the back of the last page

We grade anonymously. That means we don't want to see your name until we have graded your answers. Put your name only on the back of the last page.

This exam has 7 pages total.

There are 3 questions, each with multiple parts. Each part is worth 3 or 5 points. The total is 100 points. The third question requires a packet of computer output (your choice of JMP, R, or SAS, but only one).

Please write your answers in the enclosed spaces. Continue on the back of the page if necessary. If you do continue on the back, clearly label the appropriate question / part for each extended answer.

1. (41 pts) This problem is based on a study of the effect of diet on blood pressure. This study used data from the NHANES survey, a large nationwide survey of health and nutrition in the adult US population. It includes questions about diet and measurements of physical condition. This study considered the NHANES participants who were adult men living in Iowa in 2021. These participants are a random sample of Iowa adult men in 2021. One of the questions in the survey is how many servings of oatmeal do you eat each week? Blood pressure was measured on each participant. The study then compared blood pressure between the 16 men who ate oatmeal 3 times a week (eaters) and the 49 who never ate oatmeal (haters). The data are summarized in the following table:

Group	n	average	s.d.
Oatmeal haters	49	155.721	20.23
Oatmeal eaters	16	135.362	11.24

   (a) 5 pts. The book has a table similar to the one below. The four combinations of study features are indicated by A, B, C, and D.

   | Selection of units | Treatment assignment | |
	Randomized	Not
At random	A	B
Not at random	C	D

   Which combination (letter) is most appropriate to describe this study? Briefly explain your choice.

(b) 5 pts. The variability among observations is larger in which group of men? Support your answer with appropriate numbers.

(c) 5 pts. The mean blood pressure is more precisely estimated in which group of men? Support your answer with appropriate numbers.

(d) 5 pts. Using Kelley's rule, what number is an appropriate report of the mean for oatmeal eaters?

(e) 5 pts. Is it appropriate to assume equal variances? Briefly explain why or why not.

(f) 3 pts. The pooled sd is 18.5. How many degrees of freedom are associated with the pooled sd? Show your work.

(g) 5 pts. The 95% confidence interval for the difference in mean blood pressure is (9.7, 31.0). Based on previous research, it makes sense to test whether the difference = 25. If you did a T test of the null hypothesis that the true difference = 25, would the p-value be < 0.05, $= 0.05$, or > 0.05. Briefly explain your choice.

(h) 3 pts. The width of a confidence interval is the difference between the top and the bottom of the interval. An interval of (3, 20) is wider than an interval of (10,15). Consider a 99% interval for the difference in mean blood pressure. Will that 99% interval be narrower or wider than the 95% interval you calculated in part 1g? Briefly explain your answer.

(i) 5 pts. Results from this study are reported as "Eating oatmeal 3 times a week or more reduces your blood pressure".
Is this claim appropriate? Why or why not?

2. (34 pts.) Commercial apple orchards use to suppress fungi that produce unsightly blotches on the skin. A plant pathologist at ISU studied whether these fungal blotches could be removed by washing apples with a bleach solution. She had available 50 apples from an orchard that did not spray fungicides, so the apple skins were quite blotchy. All apples were the same variety and very similar in size. She washed each apple individually with either a bleach solution or tap water. The choice of solution was randomly assigned to each apple. 25 apples got the bleach solution; 25 got tap water. She then measured the area covered by fungal blotches on each apple. Each apple was measured once, so the data set has 50 rows of data.

She used a randomization test to test the null hypothesis that washing with bleach had no effect on the area covered by fungi. Her test statistic was the difference in average blotch area (not transformed) between the two treatments, as Tap water - Bleach. Her randomization test used 1,000 random permutations of treatments to apples.

Some summary statistics for the blotch area and for the log transformed blotch area are in the table below. The difference is calculated as tap water - bleach.

Statistic	Blotch area average	Log blotch area average
Bleach average	2.08	0.472
Tap water average	3.21	0.996
Difference	1.13	0.524
se of difference	0.490	0.195
95% conf. int.	(0.15, 2.12)	(0.13, 0.92)

Here are a histogram of all 1000 values and lists of the largest 20 and smallest 20 values in the randomization distribution.
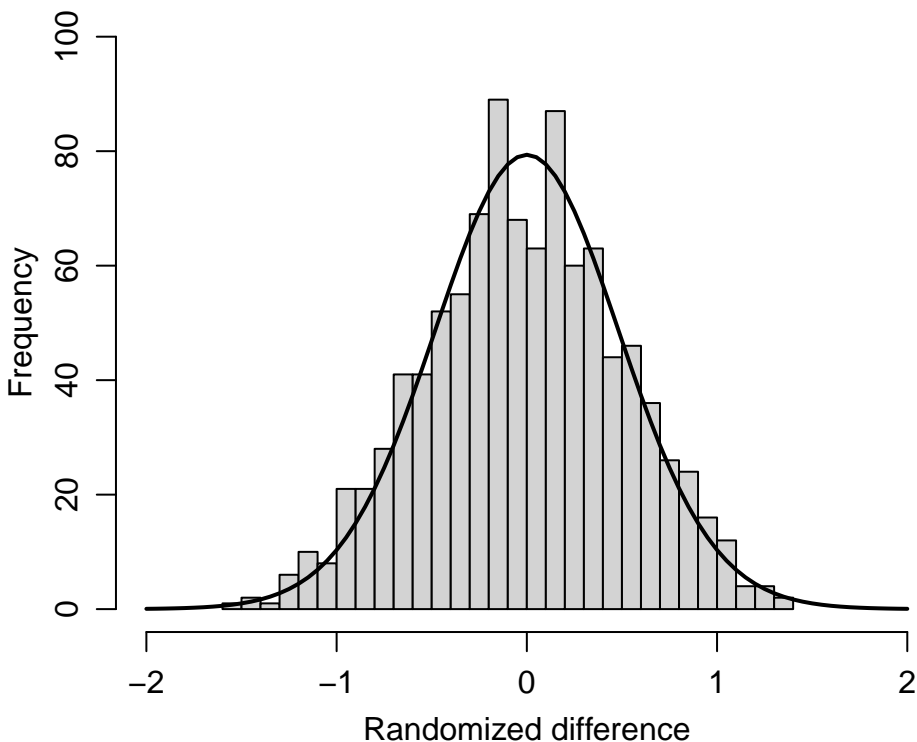
The sorted values in the randomization distribution are (10 values per line):

$$-1.55 \ -1.47 \ -1.47 \ -1.30 \ -1.30 \ -1.29 \ -1.26 \ -1.24 \ -1.23 \ -1.20$$
$$-1.17 \ -1.17 \ -1.16 \ -1.15 \ -1.15 \ -1.14 \ -1.14 \ -1.12 \ -1.12 \ -1.12$$
$$\cdots 960 \text{ more values} \cdots$$
$$1.01 \ 1.02 \ 1.02 \ 1.03 \ 1.06 \ 1.07 \ 1.07 \ 1.07 \ 1.08 \ 1.09$$
$$1.11 \ 1.12 \ 1.16 \ 1.18 \ 1.22 \ 1.22 \ 1.23 \ 1.24 \ 1.32 \ 1.33$$

(a) 3 pts. Identify the experimental unit for this study.

(b) 3 pts. Identify the observational unit for this study.

(c) 3 pts. Does this study satisfy the assumption(s) of a randomization test? Briefly explain your answer.
   If you have insufficient information to decide this, what additional information is needed?

(d) 3 pts. What is the observed value of the test statistic used in the randomization test?

(e) 5 pts. Compute the two-sided p-value for testing the null hypothesis of no effect of bleach.
Show your work
If you have insufficient information, what additional information is needed?

(f) 3 pts. Would it be appropriate to use a t-test to test the null hypothesis of no effect of bleach?
Explain why or why not.
If you have insufficient information to decide this, what additional information is needed?

You decide to analyze log transformed blotch area (no matter how you answered question 2e). Summary statistics for log transformed blotch area are in the Log blotch area column in the table above.

(g) 5 pts. Estimate the multiplicative effect that fills in this sentence:

The median blotch area when washed with bleach is _____ times that when washed with tap water.
Show your work:

(h) 3 pts. Calculate a 95% confidence interval for the multiplicative effect in the previous sentence.
Show your work.

(i) 3 pts. Imagine you are having trouble deciding whether to report results (p values and confidence intervals) for untransformed blotch area or for log transformed blotch area. In this situation, the Wilcoxon rank sum test has a big advantage. What is that?

(j) 3 pts. It also has a big disadvantage. What is that?

3. (25 pts.) The data for this question are based on surveys of the green frog in central Iowa ponds. In 2012, a graduate student randomly chose 15 ponds in central Iowa. She visited each pond and estimated the number of green frogs. In 2017, another graduate student revisited the same 15 ponds and again estimated the number of green frogs in each pond. The goal of your analysis is to understand whether green frogs are becoming more or less abundant.

The packet of computer output (either JMP, R, or SAS) contains results from the following analyses. The R and SAS packets include the code. The JMP packet includes short summaries of how a result was obtained. The paired t-test results are based on the difference, calculated as 2017 count - 2012 count.

| | Page number in packet | | |
Analysis	JMP	R	SAS
boxplots	1	1	2
summary statistics	1, 2	1	3
t-test	2	2	4
Wilcoxon rank sum test	3	2	6
normal QQ plots	3	2	5
paired t-test	4	3	7
normal QQ plot of difference	5	3	8

Use the information in this question and the computer packet to answer the following

(a) 0 pts. Circle which packet you are using for this question: JMP R SAS

(b) 5 pts. Test the hypothesis of no change in mean (or median) green frog numbers between 2012 and 2017. Report the test you used and the two-sided p-value.

(c) 5 pts. Write a 1 sentence conclusion from the results in question 3b.

(d) 5 pts. Report the estimated mean change, as 2017 count - 2012 count, and 95% confidence interval for that change.

(e) 10 pts. In the table below, list the assumptions made by your analysis. Then use the information provided above to assess each assumption. Your answer includes what diagnostic you used, whether or not that assumption is ok, and a brief explanation of your decision. Draw a horizontal line between each assumption.

For example (with made-up information):

Assumption	Diagnostic	Decision	Explanation
data aren't wierd	wierdness plot	ok	the plot has a smiley face

Your answers (Continue on the back of this page if you need more space):

Assumption	Diagnostic	Decision	Explanation

That's all! Please make sure your name is on the back of this page.