Always, Sometimes, or Never (10 points)

(10 points) The following statements are always, sometimes, or never true. Mark each statement with Always, Sometimes, or Never, depending on the truth of each statement.

1. A 99% confidence interval is wider than a 95% confidence interval.
2. In the U.S. court system, a Type I error would be imprisoning a guilty person.
3. A test rejected at a 10% significance level would be rejected at a 5% significance level.
4. A p-value is the chance of a Type I error.
5. The tails of a t-distribution with 20 degrees of freedom are thicker than the tails of a t-distribution with 10 degrees of freedom.
6. I construct a 99% confidence interval for a mean difference that contains 0. A two-sided hypothesis test on the same data is rejected at a 1% significance level.
7. The significance level is the chance that the null hypothesis is true.
8. If a p-value is greater than $\alpha = 0.05$, we accept the null hypothesis.
9. You have made a Type I error if you fail to reject the null hypothesis.
10. A test rejected at a 5% significance level would be rejected at a 10% significance level.

Matching Analysis Methods (10 points)

Match the quantities described below to the correct notation. The terms may be used once, more than once, or not at all.

1. Do hurricanes with male names act differently than hurricanes with female names? A climate scientist compares estimated damage (in US dollars) from a random sample of hurricanes with male and female names.
2. A researcher wants to compare the average blood pressure for young women taking hormonal birth control to the average blood pressure for young women not taking hormonal birth control.
3. A team of statisticians analyzes Census Bureau data to find if the average number of COVID infections in households that celebrated a birthday in the past two weeks is different from the average number of infections in households that did not celebrate a birthday.[1]
4. A student newspaper takes a random sample of students and faculty to see if the proportion of each group who has watched the Netflix series *The Chair* is different.
5. TripAdvisor estimated that in 2020, 56% of people in the US traveled for Thanksgiving. They plan to take a new sample of people to see if the value has changed in 2021.[2]
6. Experts suspect that the proportion of Democrats who have natural immunity against COVID-19 (i.e., became ill and recovered) is less than the proportion of Republicans who have natural immunity against COVID-19. [3]
7. The stated miles-per-gallon (mpg) for a Mazda CX-5 is 25. An owner of a Mazda CX-5 takes a random sample of 40 measurements to see if their car has a lower mean mpg.
8. The average price per pound of frozen turkey in 2019 was \$0.81. A poultry farmer takes a random sample of prices from different stores and brands to see if the value has changed in 2021.[4]
9. A researcher compares the rates of underweight babies born to parents with health insurance and underweight babies born to parents without health insurance to see if there is a difference.
10. Department store management claims that "most people" (i.e., more than 50%) want to shop there on Thanksgiving. An employee takes a sample of past customers to try and see if the claim is true to see if they need to schedule workers on that day.

a. One-Proportion z-test
b. Two-Proportion z-test
c. One-Sample t-test
d. Two-Sample t-test

[1] https://www.nytimes.com/2021/07/16/opinion/covid-risk-birthdays-study.html
[2] https://ir.tripadvisor.com/news-releases/news-release-details/tripadvisor-reveals-2020-thanksgiving-travel-index-over-half-56
[3] https://www.nytimes.com/2021/11/08/briefing/covid-death-toll-red-america.html
[4] https://qz.com/2076393/the-price-of-us-turkeys-has-nearly-doubled-in-two-years/

Holiday Spending (5 points)

A 2019 poll from Gallup revealed that Americans spent an average of $846 on Christmas gifts. [5] Gallup has recently completed a poll asking Americans how much they plan on spending in 2021–the responses are contained in the vector `spending`. Use the output below to answer the following questions.

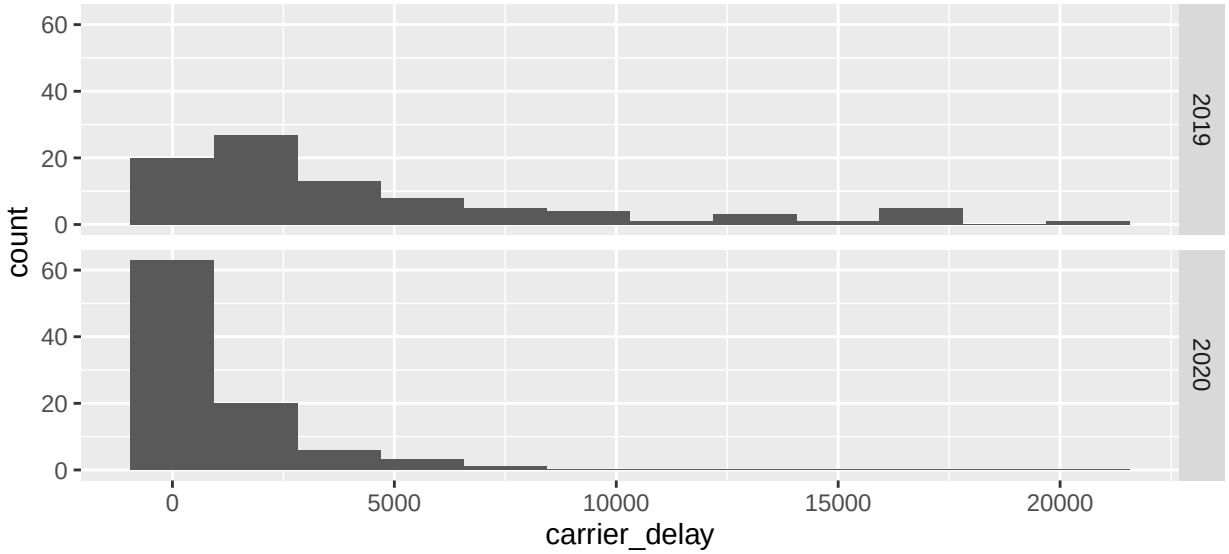
```
data:  log(spending)
t = 0.68463, df = 87, p-value = 0.2477
alternative hypothesis: true mean is greater than 6.740519
95 percent confidence interval:
 6.61831     Inf
sample estimates:
mean of x
 6.826076
```

1. Which test should be used to see if the mean log amount of money Americans are planning on spending on Christmas gifts in 2020 has increased from the mean log amount of money Americans spend on Christmas gifts in 2019, $log(\$846)$?
   (a) Two-sample t-test
   (b) One-sample t-test
   (c) One-proportion z-test
   (d) Two-proportion z-test
2. What are the correct hypotheses for testing to see if the mean log amount of money Americans are planning on spending on Christmas gifts in 2020 has changed from the mean log amount of money Americans spend on Christmas gifts in 2019, $log(\$846)$?
   (a) $H_0 : \bar{x} = log(846)$ vs. $H_A : \bar{x} \neq log(846)$
   (b) $H_0 : \bar{x} \geq log(846)$ vs. $H_A : \bar{x} < log(846)$
   (c) $H_0 : \mu \leq log(846)$ vs. $H_A : \mu > log(846)$
   (d) $H_0 : \mu = log(846)$ vs. $H_A : \mu \neq log(846)$
3. What is the test statistic?
4. What is the p-value?
5. Could you have made a Type I error? Why?
   (a) No, because we failed to reject the null
   (b) Yes, because we failed to reject the null
   (c) No, because we rejected the null.
   (d) Yes, because we rejected the null.

[5] https://news.gallup.com/poll/326654/americans-holiday-spending-intentions-strengthen-november.aspx

Airline Delays (5 points)

An analyst for Southwest Airlines is interested in seeing if their delays decreased in length from 2019 to 2020. They analyze the `carrier_delay`, which is the amount of delay directly due to Southwest (i.e., not weather, etc.), for a random selection of 2019 and 2020 trips.




```
data:  carrier_delay by year
t = 6.2791, df = 99.642, p-value = 8.945e-09
alternative hypothesis: true difference in means between group 2019 and group 2020 i
s not equal to 0
95 percent confidence interval:
 2354.061 4528.922
sample estimates:
mean in group 2019 mean in group 2020
          4565.341           1123.849
```

1. Which test should be used to see if the mean carrier delay length decreased from 2019 to 2020?
   (a) One-sample t-test
   (b) Two-proportion z-test
   (c) Two-sample t-test
   (d) One-proportion z-test
2. What are the correct hypotheses for testing to see if the mean delay decreased from 2019 to 2020?
   (a) $H_0 : \mu_{2019} \leq \mu_{2020}$ vs. $H_A : \mu_{2019} > \mu_{2020}$
   (b) $H_0 : p_{2019} \geq p_{2020}$ vs. $H_A : p_{2019} < p_{2020}$
   (c) $H_0 : p_{2019} \leq p_{2020}$ vs. $H_A : p_{2019} > p_{2020}$
   (d) $H_0 : \mu_{2019} > \mu_{2020}$ vs. $H_A : \mu_{2019} \leq \mu_{2020}$
3. What is the test statistic?

4. What is the p-value?
5. Would you trust these results?
   (a) Yes, the dataset mets all assumptions.
   (b) Yes, the dataset is big enough (i.e., $n > 30$).
   (c) No, the data are not independent.
   (d) No, the data are not normal.

Gift Giving for Pets (5 points)

In 2019, 47% of American pet owners were reported to have given their pets a holiday gift.[6] In a random sample of 360 millenial pet owners (ages 25-40), 184 report buying a gift for their pets. Use the output below to answer the following questions.

```
        1-sample proportions test with continuity correction

data:  184 out of 360
X-squared = 2.2803, df = 1, p-value = 0.131
alternative hypothesis: true p is not equal to 0.47
95 percent confidence interval:
 0.4582530 0.5637283
sample estimates:
        p
0.5111111
```

1. Which test should be used to see if the proportion of millenial American pet owners who gave their pets a gift for the holidays is different from the overall proportion of American pet owners who gave their pets a gift for the holidays?
   (a) One-sample t-test
   (b) Two-proportion z-test
   (c) Two-sample t-test
   (d) One-proportion z-test
2. What are the correct hypotheses for testing to see if the proportion of millenial American pet owners who gave their pets a gift for the holidays is different from the overall proportion of American pet owners who gave their pets a gift for the holidays?
   (a) $H_0 : \hat{p} = 0.47$ vs. $H_A : \hat{p} \neq 0.47$
   (b) $H_0 : \hat{p} \geq 0.47$ vs. $H_A : \hat{p} < 0.47$
   (c) $H_0 : p \leq 0.47$ vs. $H_A : p > 0.47$
   (d) $H_0 : p = 0.47$ vs. $H_A : p \neq 0.47$
3. Would you reject or fail to reject this test at a significance level of 0.01?
   (a) Fail to reject, since the p-value is less than $\alpha = 0.01$.
   (b) Fail to reject, since the p-value is greater than $\alpha = 0.01$.
   (c) Reject, since the p-value is less than $\alpha = 0.01$.
   (d) Reject, since the p-value is greater than $\alpha = 0.01$.
4. Is there evidence of a significant difference in the proportion of millenial American pet owners who bought their pets a holiday gift?
   (a) Yes, because we failed to reject the null hypothesis.
   (b) Yes, because we rejected the null hypothesis.

[6] https://americanpetproducts.org/Uploads/MarketResearchandData/2020COVID_HolidayData.pdf

(c) No, because we failed to reject the null hypothesis.

(d) No, because we rejected the null hypothesis.

5. Could you compare these results to a 99% confidence level?

(a) No, because the alternative is not two-sided.

(b) No, because the alternative is not upper-tailed.

(c) Yes, because the confidence level and the significance level add to 100%.

(d) Yes, because hypothesis tests can always be compared to confidence intervals.

In Person Voting (5 points)

A poll of 221 voters aged 18-29 years old showed that 57 voted in person on Election Day of 2020, while a poll of 386 voters aged 65 years and older showed that 73 voted in person on Election Day of 2020. [7]. Use the output below to answer the following questions.

```
        2-sample test for equality of proportions without continuity correction

data:  c out of c57 out of 22173 out of 386
X-squared = 3.9525, df = 1, p-value = 0.0234
alternative hypothesis: greater
95 percent confidence interval:
 0.01033563 1.00000000
sample estimates:
   prop 1    prop 2
0.2579186 0.1891192
```

1. Which test should be used to see if fewer voters aged 65 years and older voted in person than voters aged 18-29?
   (a) One-proportion z-test
   (b) One-sample t-test
   (c) Two-sample t-test
   (d) Two-proportion z-test
2. What are the correct hypotheses for testing to see if there is a difference in the proportions of people who voted in person between the two age groups?
   (a) $H_0 : p_{18-29} \geq p_{65+}$ vs. $H_A : p_{18-29} > p_{65+}$
   (b) $H_0 : p_{18-29} = p_{65+}$ vs. $H_A : p_{18-29} \neq p_{65+}$
   (c) $H_0 : p_{18-29} \leq p_{65+}$ vs. $H_A : p_{18-29} > p_{65+}$
   (d) $H_0 : p_{18-29} \neq p_{65+}$ vs. $H_A : p_{18-29} = p_{65+}$
3. Would you reject or fail to reject this test at a significance level of 0.10?
   (a) Fail to reject, since the p-value is less than $\alpha = 0.10$.
   (b) Fail to reject, since the p-value is greater than $\alpha = 0.10$.
   (c) Reject, since the p-value is less than $\alpha = 0.10$.
   (d) Reject, since the p-value is greater than $\alpha = 0.10$.
4. Is there evidence of a significant difference in the proportions of people who voted in person between the two age groups?
   (a) Yes, because we failed to reject the null hypothesis.
   (b) Yes, because we rejected the null hypothesis.
   (c) No, because we failed to reject the null hypothesis.
   (d) No, because we rejected the null hypothesis.
5. Would 0 be included in a 90% confidence level?

[7] https://docs.cdn.yougov.com/jy5um9f1tw/econTabReport.pdf

(a) No, because the alternative is not two-sided.

(b) Yes, because the confidence level and the significance level add to 100%.

(c) Yes, because the alternative is upper-tailed.

(d) There is no way to tell.