Part I: Multiple Choice (Questions 1-10) - Circle the answer of your choice.

1. A $P$-value indicates

(A) the probability that the null hypothesis is true.
(B) the probability that the alternative hypothesis is true.
(C) the probability the null is true given the observed statistic.
(D) the probability of the observed statistic given that the null hypothesis is true.
(E) the probability of the observed statistic given that the alternative hypothesis is true.

*D; by definition.*

2. A symmetric, mound-shaped distribution has a mean of 42 and a standard deviation of 7. Which of the following is true?

(A) There are more data values between 42 and 49 than between 28 and 35.
(B) It is impossible that the distribution contains a data value greater than 70.
(C) Approximately 95% of the data lie between 35 and 49.
(D) The interquartile range is approximately 14.
(E) None of these is true.

*A; you could verify this with a normalcdf calculation but 34% of data values should fall between 0 and 1 standard deviation above the mean and 13.5% should fall between –2 and –1 standard deviations below the mean.*

3. The manager of an orchard expects about 70% of his apples to exceed the weight requirement for “Grade A” designation. At least how many apples must he sample to be 90% confident of estimating the true proportion within ±4%?

(A) 19
(B) 23
(C) 89
(D) 356
(E) 505

*D; solve the equation below for n (or substitute the answer values to determine the appropriate n).*

$$1.645 \sqrt{\frac{.7(1-.7)}{n}} = .04$$
4. A company that produces iPhone cases continually monitors the strength of the cases. If the proportion of cases failing a strength test is above a specified level, the production process is halted, and the machinery inspected. Which of the following would result from a Type I error?

(A) Halting the production process when sufficient customer complaints are received
(B) Halting the production process when the strength of the case is below specifications
(C) Halting the production process when the strength of the case is within specifications
(D) Allowing the production process to continue when the case strength is below specifications
(E) Allowing the production process to continue when the case strength is within specifications

C; Type I error occurs when the null is “true” but we reject the null. The null hypothesis is the cases are within specifications. If we mistakenly reject this, production is halted because we believe they are not within specifications.

5. A sports magazine claims that home teams win 54 percent of the games in high school sports. An athletic director tests this claim by checking an SRS of 500 games and notes that the home team won 280 of them. With \( H_0 : p = 0.54 \) and \( H_0 : p \neq 0.54 \), what is the value of the test statistic?

(A) \( z = \frac{.56 - .54}{\sqrt{500(.54)(1-.54)}} \)
(B) \( z = 2 \frac{.56 - .54}{\sqrt{500(.54)(1-.54)}} \)
(C) \( z = \frac{.56 - .54}{\sqrt{(.54)(1-.54)}} \)
(D) \( z = 2 \frac{.56 - .54}{\sqrt{(.54)(1-.54)}} \)
(E) \( z = 2 \frac{.56 - .54}{\sqrt{500(.56)(1-.56)}} \)

C; the correct formula for the z test statistic is \( z = \frac{\hat{p} - p}{\sqrt{\frac{p(1-p)}{n}}} \).
6. A college alumni fund appeals for donations by phoning or emailing recent graduates. A random sample of 300 alumni shows that 40% of the 150 who were contacted by telephone actually made contributions compared to only 30% of the 150 who received email requests. Which formula calculates the 98% confidence interval for the difference in the proportions of alumni who may make donations if contacted by phone or by email?

\[
\hat{p}_1 - \hat{p}_2 \pm z* \sqrt{\frac{\hat{p}_1(1-\hat{p}_1)}{n_1} + \frac{\hat{p}_2(1-\hat{p}_2)}{n_2}}
\]

(A) \((0.4 - 0.3) \pm 2.33 \sqrt{\frac{0.35(1-0.35)}{150}}\)

(B) \((0.4 - 0.3) \pm 2.33 \sqrt{\frac{0.35(1-0.35)}{150} + \frac{0.35(1-0.35)}{150}}\)

(C) \((0.4 - 0.3) \pm 2.33 \sqrt{\frac{0.35(1-0.35)}{300}}\)

(D) \((0.4 - 0.3) \pm 2.33 \sqrt{\frac{0.4(1-0.4) + 0.3(1-0.3)}{150} + \frac{0.4(1-0.4) + 0.3(1-0.3)}{150}}\)

(E) \((0.4 - 0.3) \pm 2.33 \sqrt{\frac{0.4(1-0.4)}{300} + \frac{0.3(1-0.3)}{300}}\)

D; the correct formula is \((\hat{p}_1 - \hat{p}_2) \pm z^* \sqrt{\frac{\hat{p}_1(1-\hat{p}_1)}{n_1} + \frac{\hat{p}_2(1-\hat{p}_2)}{n_2}}\). A and C are clearly incorrect since this is a two proportion interval, B is incorrect because it does not include the sample proportions and E is incorrect since it uses the combined sample sizes.

7. Suppose that a device advertised to increase a car’s gas mileage really does not work. We test it on a small fleet of cars (with \(H_0: \) not effective), and our data results in a P-value of 0.004. What probably happens as a result of our experiment?

(A) We correctly fail to reject \(H_0\).

(B) We correctly reject \(H_0\).

(C) We reject \(H_0\), making a Type I error.

(D) We reject \(H_0\), making a Type II error.

(E) We fail to reject \(H_0\), committing Type II error.

C; since the null is true and we reject it, a Type I error has been made.
8. In a random survey of 500 women, 315 said they would rather be poor and thin than rich and fat; in a random survey of 400 men, 220 said they would rather be poor and thin than rich and fat. Is there sufficient evidence to show that the proportion of women who would rather be poor and thin than rich and fat is greater than the proportion of men who would rather be poor and thin than rich and fat?

(A) Because .63 > .55 there is evidence that the proportion of women is greater than that of men.
(B) Because .0075 < .01 there is very strong evidence that the proportion of women is greater than that of men.
(C) Because .01 < .0329 < .05 there is strong evidence that the proportion of women is greater than that of men.
(D) There is insufficient evidence that the proportion of women is greater than that of men.
(E) There is insufficient information to determine whether the proportion of women is greater than that of men.

B; using the test on the calculator, the P-value is .0076, this is strong evidence in favor of the alternate hypothesis. Note that different approaches can lead to slight rounding errors, this is not a problem.

9. Which of the following would result in the widest confidence interval?

(A) Small sample size and 95 percent confidence
(B) Small sample size and 99 percent confidence
(C) Large sample size and 95 percent confidence
(D) Large sample size and 99 percent confidence
(E) This cannot be answered without knowing an appropriate standard deviation

B; smaller samples produce wider intervals. A higher level of confidence indicates that the interval is wider because you are more confident that the interval will capture the desired parameter.

10. Not wanting to risk poor sales for a new soda flavor, a company decides to run one more taste test on potential customers, this time requiring a higher approval rating than they had for earlier tests. This higher standard of proof will increase

I. the risk of Type I error.
II. the risk of Type II error.
III. the power of the test.

(A) I
(B) II
(C) III
(D) I and II
(E) I and III

B; as \( \alpha \) decreases (higher standard of proof), \( \beta \) will increase. As \( \beta \) increases, the power of the test decreases. This sums up the relationship between \( \alpha \), \( \beta \), and power.
Part II: Free Response (Questions 11-13) – Show your work and explain your results clearly.

11. From time to time police set up roadblocks to check cars to see if the safety inspection is up to date. At one such roadblock they issued tickets for expired inspection stickers to 22 of 628 cars they stopped.

(a) Based on the results at this roadblock, construct and interpret a 95% confidence interval for the proportion of automobiles in that region whose safety inspections have expired.

\[ P - The \ true \ proportion \ of \ automobiles \ in \ that \ region \ whose \ safety \ inspections \ have \ expired. \]

\[ A \rightarrow 1. Consider \ the \ 628 \ cars \ an \ SRS \ of \ all \ cars. \]

\[ 2. It \ is \ reasonable \ to \ assume \ N > 10(628). \]

\[ 3. 22 \ and \ 628 - 22 = 606 \ are \ both \ greater \ than \ 10. \]

\[ N - One \ Proportion \ 95\% \ Confidence \ Interval \]

\[ I - 0.035 \pm 1.960 \sqrt{\frac{0.035(1-0.035)}{628}} \]

\[ C - We \ are \ 95\% \ confident \ that \ the \ true \ proportion \ of \ automobiles \ in \ that \ region \ whose \ safety \ inspections \ have \ expired \ is \ between \ 0.021 \ and \ 0.049. \]

(b) Explain the meaning of the confidence level of 95% confidence.

This method will produce intervals that capture the population parameter about 95 out of 100 times.
12. A university recruiter claims that 60 percent of its basketball and football players graduate in 4 years. A reporter contacts an SRS of players from the past 20 years and finds that only 46 out of 88 had graduated in 4 years. Is there sufficient evidence to write an article disputing the university claim? Give statistical justification for your conclusion.

\[ P - The \ true \ proportion \ of \ basketball \ and \ football \ players \ that \ graduate \ in \ 4 \ years. \]
\[ H - \]
\[ H_0 : p = .6 \]
\[ H_a : p < .6 \]

\[ A - 1. \ Given \ an \ SRS. \]
\[ 2. \ We \ can \ assume \ that \ N > 10(88). \]
\[ 3. \ \frac{88}{.6} \geq 10 \ \text{and} \ \frac{88}{1 - .6} \geq 10 \]

\[ N - One \ Proportion \ z \ Test \]
\[ T - z = \frac{.523 - .6}{.6(1 - .6)} = -1.474 \]
\[ \sqrt{\frac{88}{.6(1 - .6)}} \]
\[ O - P(z < -1.474) = .070 \]

\[ M - \text{Since} \ .07 > .05, \ \text{we fail to reject the null hypothesis.} \]
\[ S - \text{We do not have evidence that the true proportion of basketball and football players that graduate in 4 years is less than .6.} \]
13. A city council must decide whether to fund a new “welfare-to-work” program to assist long-time unemployed people in finding jobs. This program would help clients fill out job applications and give them advice about dealing with job interviews. A six-month trial has just ended. At the start of this trial a number of unemployed residents were randomly divided into two groups; one group went through the help program and the other group did not. Data about employment at the end of this trial are shown in the table. Should the city council fund this program? Test an appropriate hypothesis and state your conclusion.

<table>
<thead>
<tr>
<th>Current Job Status</th>
<th>Employed</th>
<th>Unemployed</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1 (Help program)</td>
<td>20</td>
<td>34</td>
<td>54</td>
</tr>
<tr>
<td>Group 2 (No help)</td>
<td>13</td>
<td>33</td>
<td>46</td>
</tr>
</tbody>
</table>

\[ P - \text{The true difference in the proportion of the Help program clients finding jobs and the no help program.} \]

\[ H_0 : p_{Help} = p_{No\, Help} \]

\[ H_a : p_{Help} > p_{No\, Help} \]

\[ A - 1. \text{Random assignment to the two groups.} \]

\[ 2. \text{The number of successes/failures (20, 13, 34, and 33) are all greater than 10.} \]

\[ N - \text{Two Proportion z-Test} \]

\[ z = \frac{.370 - .283}{\sqrt{.33(1-.33)\left(\frac{1}{54} + \frac{1}{46}\right)}} = .922 \]

\[ O - P(z > .922) = .178 \]

\[ M - \text{Since the P-value is really large, we fail to reject the null hypothesis.} \]

\[ S - \text{We do not have evidence the true proportion of Help program clients finding jobs is greater than the no help program. As a result the city should probably not fund the program.} \]