1. We are interested in evaluating the effect of a natural product on reducing blood pressure. This is done by comparing the mean reduction in blood pressure of a treatment (natural product) group and a placebo group using a two-sample t test. The standard deviations are approximately the same, so the researchers will use a pooled t test. Based on previous work, the researchers are able to specify a common sample standard deviation. The researchers have specified $\mu_2 - \mu_1 = 7$ as an alternative they would like to be able to detect with $\alpha = 0.01$. Random samples of size 50 are selected independently from each group, and the resulting test is found to have a power of 80%. If the researchers now decide they are interested in the alternative $\mu_2 - \mu_1 = 5$ instead, then the power of the study for this alternative

A) would be less than 80%.
B) would be greater than 80%.
C) would still be 80%.
D) could be either less than or greater than 80%, depending on whether the natural product is effective.
E) would vary depending on the standard deviation of the data.

Use the following to answer questions 2-4:

Some researchers have conjectured that stem-pitting disease in peach tree seedlings might be controlled with weed and soil treatment. An experiment was conducted to compare peach tree seedling growth with soil and weeds treated with one of two herbicides. In a field containing 20 seedlings, 10 were randomly selected from throughout the field and assigned to receive Herbicide A. The remaining 10 seedlings were to receive Herbicide B. Soil and weeds for each seedling were treated with the appropriate herbicide, and at the end of the study period, the height (in centimeters) was recorded for each seedling. A box plot of each data set showed no indication of non-normality. The following results were obtained:

Herbicide A: $\bar{X}_1 = 94.5$ cm $s_1 = 10$ cm
Herbicide B: $\bar{X}_2 = 109.1$ cm $s_2 = 9$ cm

2. Referring to the information above, a 95% confidence interval for $\mu_2 - \mu_1$ (using the conservative value for the degrees of freedom) is

A) $14.6 \pm 7.36$.
B) $14.6 \pm 7.80$.
C) $14.6 \pm 9.62$.
D) $14.6 \pm 13.93$.
E) $14.6 \pm 33.18$. 
3. Referring to the information above, suppose we wished to determine if there tended to be a significant difference in mean height for the seedlings treated with the different herbicides. To answer this question, we decide to test the hypotheses $H_0: \mu_2 - \mu_1 = 0$, $H_a: \mu_2 - \mu_1 \neq 0$. Based on our data, the value of the two-sample $t$ test statistic is
A) 14.60.
B) 7.80.
C) 3.43.
D) 2.54.
E) 1.14.

4. Referring to the information above, suppose we wished to determine if there tended to be a significant difference in mean height for the seedlings treated with the different herbicides. To answer this question, we decide to test the hypotheses $H_0: \mu_2 - \mu_1 = 0$, $H_a: \mu_2 - \mu_1 \neq 0$. The 90% confidence interval is $14.6 \pm 7.80$ cm. Based on this confidence interval,
A) we would not reject the null hypothesis of no difference at the 0.10 level.
B) we would reject the null hypothesis of no difference at the 0.10 level.
C) we would reject the null hypothesis of no difference at the 0.05 level.
D) the $P$-value is less than 0.10.
E) both C) and D) are correct.

5. Researchers compared two groups of competitive rowers: a group of skilled rowers and a group of novices. The researchers measured the angular velocity of each subject's right knee, which describes the rate at which the knee joint opens as the legs push the body back on the sliding seat. The sample size $n$, the sample means, and the sample standard deviations for the two groups are given below.

<table>
<thead>
<tr>
<th>Group</th>
<th>$n$</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skilled</td>
<td>16</td>
<td>4.2</td>
<td>0.6</td>
</tr>
<tr>
<td>Novice</td>
<td>16</td>
<td>3.2</td>
<td>0.8</td>
</tr>
</tbody>
</table>

The researchers wished to test the hypotheses
$H_0$: the mean knee velocities for skilled and novice rowers are the same
$H_a$: the mean knee velocity for skilled rowers is larger than for novice rowers

The data showed no strong outliers or strong skewness, so the researchers decided to use the two-sample $t$ test. The value of the $t$ test statistic is
A) 0.0002.
B) 1.0.
C) 1.25.
D) 2.0.
E) 4.0.
A researcher wished to test the effect of the addition of extra calcium to yogurt on the “tastiness” of yogurt. A collection of 200 adult volunteers was randomly divided into two groups of 100 subjects each. Group 1 tasted yogurt containing the extra calcium. Group 2 tasted yogurt from the same batch as group 1 but without the added calcium. Both groups rated the flavor on a scale of 1 to 10, with 1 being “very unpleasant” and 10 being “very pleasant.” The mean rating for group 1 was $\bar{X}_1 = 6.5$ with a standard deviation of $s_1 = 1.5$. The mean rating for group 2 was $\bar{X}_2 = 7.0$ with a standard deviation of $s_2 = 2.0$. Assume the two groups' ratings are independent. Let $\mu_1$ and $\mu_2$ represent the mean ratings we would observe for the entire population represented by the volunteers if all members of this population tasted, respectively, the yogurt with and without the added calcium.

6. Referring to the information above, assuming two sample $t$ procedures are safe to use, a 90% confidence interval for $\mu_1 - \mu_2$ (using the conservative value for the degrees of freedom) is
   A) $-0.5 \pm 0.25$.
   B) $-0.5 \pm 0.32$.
   C) $-0.5 \pm 0.42$.
   D) $-0.5 \pm 0.5$.
   E) $-0.5 \pm 0.58$.

7. Referring to the information above, suppose the researcher had wished to test the hypotheses $H_0: \mu_1 = \mu_2$, $H_a: \mu_1 < \mu_2$. The $P$-value for the test (using the conservative value for the degrees of freedom) is
   A) larger than 0.10.
   B) between 0.05 and 0.10.
   C) between 0.01 and 0.05.
   D) between 0.001 and 0.01.
   E) below 0.001.

8. Referring to the information above, which of the following would lead us to believe that the $t$ procedures were not safe to use here?
   A) The sample medians and means for the two groups were slightly different.
   B) The distributions of the data were moderately skewed.
   C) The data are integers between 1 and 10 and so cannot be normal.
   D) Only the most severe departures from normality would lead us to believe the $t$ procedures were not safe to use.
   E) The standard deviations from both samples were very different from each other.
9. Referring to the information above, if we had used the more accurate software approximation to the degrees of freedom, we would have used which of the following as the number of degrees of freedom for the $t$ procedures?
A) 199.
B) 198.
C) 190.
D) 183.
E) 99.

Use the following to answer questions 10-13:

A sports writer wished to see if a football filled with helium travels farther, on average, than a football filled with air. To test this, the writer used 18 adult male volunteers. These volunteers were randomly divided into two groups of nine subjects each. Group 1 kicked a football filled with helium to the recommended pressure. Group 2 kicked a football filled with air to the recommended pressure. The mean yardage for group 1 was $\bar{X}_1 = 30$ yards with a standard deviation of $s_1 = 8$ yards. The mean yardage for group 2 was $\bar{X}_2 = 26$ yards with a standard deviation of $s_2 = 6$ yards. Assume the two groups of kicks are independent. Let $\mu_1$ and $\mu_2$ represent the mean yardage we would observe for the entire population represented by the volunteers if all members of this population kicked, respectively, a helium- and an air-filled football.

10. Referring to the information above, assuming two sample $t$ procedures are safe to use, a 99% confidence interval for $\mu_1 - \mu_2$ (using the conservative value for the degrees of freedom) is
A) 4 ± 4.7 yards.
B) 4 ± 6.2 yards.
C) 4 ± 7.7 yards.
D) 4 ± 8.6 yards.
E) 4 ± 11.2 yards.

11. Referring to the information above, suppose the researcher had wished to test the hypotheses $H_0$: $\mu_1 = \mu_2$, $H_a$: $\mu_1 > \mu_2$. The $P$-value for the test (using the conservative value for the degrees of freedom) is
A) larger than 0.10.
B) between 0.05 and 0.10.
C) between 0.01 and 0.05.
D) between 0.001 and 0.01.
E) below 0.001.
12. Referring to the information above, to which of the following would it have been most important that the subjects be blind during the experiment?
   A) The identity of the sports writer.
   B) Whether or not the balls were of regulation size and weight.
   C) The method they were to use in kicking the ball.
   D) Whether the ball they were kicking was filled with helium or air.
   E) The direction in which they were to kick the ball.

13. Referring to the information above, if we had used the more accurate software approximation to the degrees of freedom, we would have used which of the following as the number of degrees of freedom for the \( t \) procedures?
   A) 16.
   B) 14.
   C) 12.
   D) 9.
   E) 8.

Use the following to answer questions 14-16:

A researcher wished to compare the average amount of time spent in extracurricular activities by high school students in a suburban school district with that in a school district of a large city. The researcher obtained an SRS of 60 high school students in a large suburban school district and found the mean time spent in extracurricular activities per week to be \( \bar{X}_1 = 6 \) hours with a standard deviation of \( s_1 = 3 \) hours. The researcher also obtained an independent SRS of 40 high school students in a large city school district and found the mean time spent in extracurricular activities per week to be \( \bar{X}_2 = 4 \) hours with a standard deviation of \( s_2 = 2 \) hours. Let \( \mu_1 \) and \( \mu_2 \) represent the mean amount of time spent in extracurricular activities per week by the populations of all high school students in the suburban and city school districts, respectively.

14. Referring to the information above, assuming two sample \( t \) procedures are safe to use, a 95\% confidence interval for \( \mu_1 - \mu_2 \) (using the conservative value for the degrees of freedom) is
   A) \( 2 \pm 0.5 \) hours.
   B) \( 2 \pm 0.84 \) hours.
   C) \( 2 \pm 1.01 \) hours.
   D) \( 2 \pm 1.34 \) hours.
   E) \( 2 \pm 1.41 \) hours.
15. Referring to the information above, suppose the researcher had wished to test the hypotheses $H_0: \mu_1 = \mu_2$, $H_a: \mu_1 \neq \mu_2$. The $P$-value for the test (using the conservative value for the degrees of freedom) is
A) larger than 0.10.
B) between 0.05 and 0.10.
C) between 0.01 and 0.05.
D) between 0.001 and 0.01.
E) below 0.001.

16. Referring to the information above, if we had used the more accurate software approximation to the degrees of freedom, we would have used which of the following as the number of degrees of freedom for the $t$ procedures?
A) 99.
B) 98.
C) 97.
D) 60.
E) 50.

17. A researcher wished to compare the effect of two stepping heights (low and high) on heart rate in a step-aerobics workout. A collection of 50 adult volunteers was randomly divided into two groups of 25 subjects each. Group 1 did a standard step-aerobics workout at the low height. The mean heart rate at the end of the workout for the subjects in group 1 was $\overline{X}_1 = 90.00$ beats per minute with a standard deviation of $s_1 = 9$ beats per minute. Group 2 did the same workout but at the high step height. The mean heart rate at the end of the workout for the subjects in group 2 was $\overline{X}_2 = 95.08$ beats per minute with a standard deviation of $s_2 = 12$ beats per minute. Assume the two groups are independent and the data are approximately normal. Let $\mu_1$ and $\mu_2$ represent the mean heart rates we would observe for the entire population represented by the volunteers if all members of this population did the workout using the low or high step height, respectively. Suppose the researcher had wished to test the hypotheses $H_0: \mu_1 = \mu_2$, $H_a: \mu_1 < \mu_2$. The $P$-value for the test (using the conservative value for the degrees of freedom) is
A) larger than 0.10.
B) between 0.05 and 0.10.
C) between 0.01 and 0.05.
D) between 0.001 and 0.01.
E) less than 0.001.

Use the following to answer questions 18-19:

An SRS of size 100 is taken from a population having proportion 0.8 of successes. An independent SRS of size 400 is taken from a population having proportion 0.5 of successes.
18. Referring to the information above, the sampling distribution for the difference in the sample proportions, \( \hat{p}_1 - \hat{p}_2 \), has mean
A) equal to the smaller of 0.8 and 0.5.
B) 0.56.
C) 0.3.
D) 0.15.
E) The mean cannot be determined without knowing the sample results.

19. Referring to the information above, the sampling distribution for the difference in the sample proportions, \( \hat{p}_1 - \hat{p}_2 \), has standard deviation
A) 1.3.
B) 0.40.
C) 0.047.
D) 0.055.
E) 0.002.

20. An SRS of 100 of a certain popular model car in 1993 found that 20 had a certain minor defect in the brakes. An SRS of 400 of this model car in 1994 found that 50 had the minor defect in the brakes. Let \( p_1 \) and \( p_2 \) be the proportion of all cars of this model in 1993 and 1994, respectively, that actually contain the defect. A 90% confidence interval for \( p_1 - p_2 \) is 0.075 ± 0.071.

Suppose the sample of 1993 cars consisted of only 10 cars, of which two had the minor brake defect. Suppose also the sample of 1994 cars consisted of only 40 cars, of which five had the minor brake defect. A 90% confidence interval for \( p_1 - p_2 \) is now
A) the same as that for the original sample of 100 and 400 cars.
B) much wider than that for the original sample of 100 and 400 cars.
C) the same as 99% for the original sample of 100 and 400 cars.
D) unsafe to compute, since it is unsafe to use the normal distribution to approximate the sampling distribution of \( \hat{p}_1 - \hat{p}_2 \).
E) much narrower than that for the original sample of 100 and 400 cars.

Use the following to answer questions 21-22:

In a large Midwestern university (with the class of entering freshmen being on the order of 6000 or more students), an SRS of 100 entering freshmen in 1993 found that 20 finished in the bottom third of their high school class. Admission standards at the university were tightened in 1995. In 1997, an SRS of 100 entering freshmen found that 10 finished in the bottom third of their high school class. Let \( p_1 \) be the proportion of all entering freshmen in 1993 who graduated in the bottom third of their high school class, and let \( p_2 \) be the proportion of all entering freshmen in 1997 who graduated in the bottom third of their high school class.
21. Referring to the information above, a 99% confidence interval for \( p_1 - p_2 \) is
   A) \( 0.10 \pm 0.050 \).
   B) \( 0.10 \pm 0.083 \).
   C) \( 0.10 \pm 0.098 \).
   D) \( 0.10 \pm 0.129 \).
   E) \( 0.10 \pm 0.166 \).

22. Referring to the information above, is there evidence that the proportion of freshmen who graduated in the bottom third of their high school class in 1997 has been reduced as a result of the tougher admission standards adopted in 1995, compared to the proportion in 1993? To determine this, you test the hypotheses \( H_0: p_1 = p_2 \), \( H_a: p_1 > p_2 \). The \( P \)-value of your test is
   A) greater than 0.10.
   B) between 0.05 and 0.10.
   C) between 0.01 and 0.05.
   D) between 0.001 and 0.01.
   E) below 0.001.

23. A manufacturer receives parts independently from two suppliers. An SRS of 400 parts from supplier 1 finds 20 defectives. An SRS of 100 parts from supplier 2 finds 10 defectives. Let \( p_1 \) and \( p_2 \) be the proportions of all parts from suppliers 1 and 2, respectively, that are defective. A 95% confidence interval for \( p_1 - p_2 \) is
   A) \( -0.05 \pm 0.063 \).
   B) \( -0.05 \pm 0.053 \).
   C) \( -0.05 \pm 0.052 \).
   D) \( -0.05 \pm 0.032 \).
   E) \( 0.05 \pm 0.032 \).

Use the following to answer questions 24-25:

An SRS of 100 flights by Airline 1 showed that 64 were on time. An SRS of 100 flights by Airline 2 showed that 80 were on time. Let \( p_1 \) be the proportion of on-time flights for all Airline 1 flights, and let \( p_2 \) be the proportion of all on-time flights for all Airline 2 flights.
24. Referring to the information above, a 95% confidence interval for the difference \( p_1 - p_2 \) is

A) \(-0.16 \pm 0.062\).
B) \(-0.16 \pm 0.122\).
C) \(-0.16 \pm 0.104\).
D) \(-0.16 \pm 0.103\).
E) \(0.16 \pm 0.062\).

25. Referring to the information above, is there evidence of a difference in the on-time rate for the two airlines? To determine this, you test the hypotheses \( H_0: p_1 = p_2, H_a: p_1 \neq p_2 \). The \( P \)-value of your test is

A) greater than 0.10.
B) between 0.05 and 0.10.
C) between 0.01 and 0.05.
D) between 0.001 and 0.01.
E) below 0.001.

Use the following to answer questions 26-27:

An agricultural researcher wishes to see if a kelp extract helps prevent frost damage on tomato plants. Two similar small plots are planted with the same variety of tomato. Plants in both plots are treated identically, except that the plants on plot 1 are sprayed weekly with a kelp extract, while the plants on plot 2 are not. After the first frost in the autumn, the percentage of damaged fruit is determined. For plants in plot 1, 20 of the 100 tomatoes on the vine exhibited damage. For plants in plot 2, 36 of the 100 tomatoes on the vine showed damage. Let \( p_1 \) be the actual proportion of all tomatoes of this variety that would experience crop damage under the kelp treatment, and let \( p_2 \) be the actual proportion of all tomatoes of this variety that would experience crop damage under the no-kelp treatment, assuming that the tomatoes are grown under conditions similar to those in the experiment.

26. Referring to the information above, a 99% confidence interval for \( p_1 - p_2 \) is

A) \(-0.16 \pm 0.062\).
B) \(-0.16 \pm 0.122\).
C) \(-0.16 \pm 0.161\).
D) \(0.16 \pm 0.062\).
E) \(0.16 \pm 0.161\).
27. Referring to the information above, is there evidence of a decrease in the proportion of tomatoes suffering frost damage for tomatoes sprayed with kelp extract? To determine this, you test the hypotheses $H_0: \ p_1 = p_2, \ H_a: \ p_1 < p_2$. The $P$-value of your test is
A) greater than 0.10.
B) between 0.05 and 0.10.
C) between 0.01 and 0.05.
D) between 0.001 and 0.01.
E) below 0.001.

Use the following to answer questions 28-29:

An SRS of 25 male faculty members at a large university found that 10 felt that the university was supportive of female and minority faculty. An independent SRS of 20 female faculty found that five felt that the university was supportive of female and minority faculty. Let $p_1$ represent the proportion of all male faculty members at the university and $p_2$ represent the proportion of all female faculty members at the university who hold the stated opinion.

28. Referring to the information above, a 95% confidence interval for $p_1 - p_2$ is
A) $0.15 \pm 0.355$.
B) $0.15 \pm 0.270$.
C) $0.15 \pm 0.227$.
D) $0.15 \pm 0.138$.
E) $0.15 \pm 0.168$.

29. Referring to the information above, is there evidence that the proportion of male faculty members who felt the university was supportive of female and minority faculty is larger than the corresponding proportion for female faculty members? To determine this, you test the hypotheses $H_0: \ p_1 = p_2, \ H_a: \ p_1 > p_2$. The $P$-value of your test is
A) larger than 0.10.
B) between 0.05 and 0.10.
C) between 0.01 and 0.05.
D) between 0.001 and 0.01.
E) below 0.001.
A sociologist is studying the effect of having children within the first three years of marriage on the divorce rate. From city marriage records, she selects a random sample of 400 couples that were married between 1985 and 1990 for the first time, with both members of the couple being between the ages of 20 and 25. Of the 400 couples, 220 had at least one child within the first three years of marriage. Of the couples that had children, 83 were divorced within five years, while of the couples that didn't have children, only 52 were divorced within three years. Suppose \( p_1 \) is the proportion of couples married in this time frame that had a child within the first three years and were divorced within five years and \( p_2 \) is the proportion of couples married in this time frame that did not have a child within the first two years and were divorced within five years.

30. Referring to the information above, the estimate of \( p_1 - p_2 \) is
A) 0.0775.
B) 0.0884.
C) 0.3100.
D) 0.3375.
E) 0.3773.

31. Referring to the information above, the sociologist had hypothesized that having children early would increase the divorce rate. She tested the one-sided alternative and obtained a \( P \)-value of 0.0314. The correct conclusion is that
A) if you want to decrease your chances of getting divorced, it is best to wait several years before having children.
B) having more children increases the risk of divorce during the first 5 years of marriage.
C) if you want to decrease your chances of getting divorced, it is best not to marry when you are closer to 30 years old.
D) it is best not to have children.
E) there is evidence of an association between divorce rate and having children early in a marriage.
Answer Key

1. A
2. C
3. C
4. B
5. E
6. C
7. C
8. D
9. D
10. E
11. A
12. D
13. B
14. C
15. E
16. B
17. B
18. C
19. C
20. D
21. D
22. C
23. A
24. B
25. C
26. C
27. D
28. B
29. A
30. B
31. E