Step 3: Subtract the margin of error from and add the margin of error to the point estimate.

$$\text{Lower endpoint: } (\bar{x}_1 - \bar{x}_2) - E = -0.7 - 2.003538$$
$$\approx -2.7$$
$$\text{Upper endpoint: } (\bar{x}_1 - \bar{x}_2) + E = -0.7 + 2.003538$$
$$\approx 1.3$$

This confidence interval can be expressed mathematically as (–2.7, 1.3).

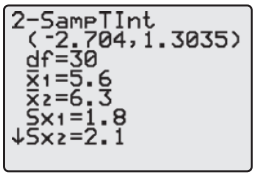
TI-83/84 Plus: We can compute the confidence interval in one step by using the calculator. Since we already have the sample statistics, go to STAT > TESTS and choose 2-SampTInt. The general formula for this computation is 2-SampTInt($\bar{x}_1$, s_1, n_1, $\bar{x}_2$, s_2, n_2, C-Level, Pooled). If the data is pooled, select Yes. If the data is not pooled, select No. All of the other statistics are given to us in the problem.

$$\bar{x}_1 = 5.6 \; ; \; s_1 = 1.8 \; ; \; n_1 = 12$$

$$\bar{x}_2 = 6.3 \; ; \; s_2 = 2.1 \; ; \; n_2 = 20$$

$$C\text{-}Level = 0.99$$

$$Pooled = \text{Yes}$$



The confidence interval returned by the calculator is (–2.7, 1.3) as shown in the margin.

Therefore, we are 99% confident that the population mean birth weight for babies whose mothers took the pain reliever while pregnant is between 2.7 pounds less than and 1.3 pounds more than the population mean birth weight for babies whose mothers didn't take the pain reliever. Since the confidence interval contains 0, there is not sufficient statistical evidence to indicate that the mean birth weights are different for the two populations. Thus, we cannot conclude that the pain reliever causes lower birth weights.

9.2 Section Exercises

Note: *For all exercises in this section, you may assume that the requirements mentioned in this section are met; namely, all samples are independent, simple random samples, both population standard deviations are unknown, and either both sample sizes are at least 30 or both population distributions are approximately normal.*

Critical Values for Confidence Intervals for Differences between Two Population Means (σ Unknown, Independent Samples)

Determine the critical value for a confidence interval for the difference between the two population means using the given information.

1. $c = 0.95$, population variances assumed to be equal, $n_1 = 11$, $n_2 = 20$
2. $c = 0.99$, population variances assumed to be equal, $n_1 = 9$, $n_2 = 6$
3. $c = 0.90$, population variances assumed to be unequal, $n_1 = 14$, $n_2 = 12$
4. $c = 0.95$, population variances assumed to be unequal, $n_1 = 25$, $n_2 = 26$
5. $c = 0.95$, population variances assumed to be unequal, $n_1 = 4$, $n_2 = 7$
6. $c = 0.99$, population variances assumed to be equal, $n_1 = 22$, $n_2 = 18$

7. $\alpha = 0.02$, population variances assumed to be equal, $n_1 = 13$, $n_2 = 8$
8. $\alpha = 0.05$, population variances assumed to be equal, $n_1 = 11$, $n_2 = 16$

Margins of Error of Confidence Intervals for Differences between Two Population Means (σ Unknown, Independent Samples)

Calculate the margin of error of a confidence interval for the difference between the two population means using the given information.

9. Population variances assumed to be unequal, $t_{0.01} = 2.764$, $s_1 = 6$, $n_1 = 16$, $s_2 = 5$, $n_2 = 11$
10. Population variances assumed to be equal, $t_{0.025} = 2.021$, $s_1 = 2$, $n_1 = 22$, $s_2 = 3$, $n_2 = 20$
11. Population variances assumed to be equal, $\alpha = 0.01$, $s_1 = 10$, $n_1 = 15$, $s_2 = 13$, $n_2 = 10$
12. Population variances assumed to be unequal, $c = 0.90$, $s_1 = 2$, $n_1 = 6$, $s_2 = 5$, $n_2 = 5$

Confidence Intervals for Differences between Two Population Means (σ Unknown, Independent Samples)

Construct and interpret each specified confidence interval.

13. Different breeds of dogs produce different-sized litters. Wesley believes that his Coonhounds will have litters that are twice as big as his Schnauzers. He has ten female Coonhounds and the mean size of their most recent litters was 11.0 puppies with a standard deviation of 3.0 puppies. Wesley also has nine female Schnauzers, whose most recent litters had a mean litter size of 5.0 puppies with a standard deviation of 2.0 puppies. Assume that the population variances are not the same. Create and interpret a 90% confidence interval to estimate the true difference between the mean sizes of the litters of Wesley's Coonhounds and Schnauzers.
14. Midwives claim that a water birth reduces the amount of pain the mother perceives. To test this theory, one midwife asks six of her clients who had a water birth and eight of her clients who did not have a water birth to rate their pain on a scale of 1 to 10. The mean pain score of mothers who had a water birth was a 7.0 with a standard deviation of 1.2. The mean pain score of mothers who did not have a water birth was 9.0 with a standard deviation of 0.9. Construct and interpret an 80% confidence interval for the true difference between the pain scores of mothers who had a water birth and mothers who did not. Assume that the variances of the two populations are not equal.
15. Steve believes that his wife's cell phone battery does not last as long as his cell phone battery. On eight different occasions, he measured the length of time his cell phone battery lasted and calculated that the mean was 24.3 hours with a standard deviation of 6.1 hours. He measured the length of time his wife's cell phone battery lasted on nine different occasions and calculated a mean of 22.8 hours with a standard deviation of 8.3 hours. Construct and interpret a 95% confidence interval for the true difference in battery life between Steve's cell phone and his wife's. Assume that the population variances are the same.
16. Dentists believe that a diet low in sugary foods can reduce the number of cavities in children. Ten children whose diets are believed to be high in sugar are examined and the mean number of cavities is 3.0 with a standard deviation of 0.7. Twelve children whose diets are believed to be low in sugar are examined and the mean number of cavities is 1.8 with a standard deviation of 0.6. Construct and interpret a 99% confidence interval for the true difference between the mean numbers of cavities for children whose diets are high in sugar and those whose diets are low in sugar. Assume that the variances of the two populations are the same.

17. A company that manufactures baseball bats believes that its new bat will allow players to hit the ball 30 feet farther than its current model. The owner hires a professional baseball player known for hitting home runs to hit ten balls with each bat and he measures the distance each ball is hit to test the company's claim. The results of the batting experiment are shown in the following table. Construct and interpret a 90% confidence interval for the true difference between the mean distance hit with the new model and the mean distance hit with the older model. Assume that the variances of the two populations are the same.

Hitting Distance (in Feet)

New Model	Old Model
235	200
240	210
253	231
267	218
243	210
237	209
250	210
241	229
251	234
248	231

18. A marketing firm is doing research for an Internet-based company. It wants to appeal to the age group of people who spend the most money online. The company wants to know if there is a difference in the mean amount of money people spend per month on Internet purchases depending on their age bracket. The marketing firm looked at two age groups, 18–24 years and 25–30 years, and collected the data shown in the following table. Assume that the population variances are not the same. Construct and interpret an 80% confidence interval to estimate the true difference between the mean amounts of money per month that people in these two age groups spend on Internet purchases.

Internet Spending per Month

	18–24 Years	25–30 Years
Mean Amount Spent	\$52.00	\$45.49
Standard Deviation	\$21.30	\$13.19
Sample Size	18	25

19. Is it worth pursuing a doctoral degree in education if you already have an undergraduate degree? One way to help make this decision is to look at the mean incomes of these two groups. Suppose that 19 people with bachelor's degrees in education were surveyed. Their mean annual salary was \$28,500 with a standard deviation of \$6800. Eleven people with doctoral degrees in education were found to have a mean annual salary of \$55,500 with a standard deviation of \$10,200. Assume that the population variances are not the same. Construct and interpret a 90% confidence interval to estimate the true difference between the mean salaries for people with doctoral degrees and undergraduate degrees in education.

20. In evaluating his teaching, a literature professor decides to have a random sample of 15 students rate him on a scale of 1–10 with 10 being excellent. After getting the results, a mean of 6.2 with a standard deviation of 1.5, he decides to make an effort to improve his teaching. Next semester, for a random sample of 13 students, the results are a mean of 7.5 with a standard deviation of 1.6. Construct and interpret a 95% confidence interval to estimate the true difference between the literature professor's mean ratings from semester to semester. You can assume that the population variances are the same.

21. To conform to market trends, a prominent syrup manufacturer is changing the design of its syrup bottle from a tall slender bottle to a shorter rounder bottle that fits more easily in a microwave oven. The shareholders are concerned that the mean amount of syrup in each bottle remains the same. A sample of 16 bottles of the older design has a mean capacity of 36.20 fluid ounces (fl oz) with a standard deviation of 0.90 fl oz, and a sample of 20 bottles from the new design has a mean capacity of 35.90 fl oz with a standard deviation of 0.73 fl oz. Because the same machine is being used to fill the bottles, you may assume that the population variances are the same. Construct and interpret a 90% confidence interval to estimate the difference between the mean volumes for the bottles.

22. A researcher is interested in exploring the relationship between calcium intake and weight loss. Two different groups, each with 25 dieters, are chosen for the study. Group A is required to follow a specific diet and exercise regimen, and also take a 500-mg supplement of calcium each day. Group B is required to follow the same diet and exercise regimen, but with no supplemental calcium. After six months on the program, the members of Group A had lost a mean of 12.7 pounds with a standard deviation of 2.2 pounds. The members of Group B had lost a mean of 10.8 pounds with a standard deviation of 2.0 pounds during the same time period. Assume that the population variances are not the same. Create and interpret a 95% confidence interval to estimate the true difference between the mean amounts of weight lost by dieters who supplement with calcium and those who do not.

23. Gavin likes to grow tomatoes in the summer, and each year he experiments with ways to improve his crop. This summer, he wants to determine whether the new fertilizer he has seen advertised will increase the mean number of tomatoes produced per plant. Being careful to control the conditions in his garden, he uses the old fertilizer on 12 tomato plants and the new fertilizer on the other 8 plants. Over the course of the growing season, he calculates a mean of 18.2 tomatoes per plant for the old fertilizer, with a standard deviation of 1.9 tomatoes. He calculates a mean of 21.4 tomatoes per plant for the new fertilizer, with a standard deviation of 2.6 tomatoes. Create and interpret a 90% confidence interval for the true difference in tomato production. Assume that the population variances are the same.

24. A retailer is interested in comparing the shopping habits of customers as different types of music play throughout the store. One day when the store played slow instrumental music, the 17 customers who made purchases spent a mean of $84 with a standard deviation of $20. The next day, the store played upbeat instrumental music, and the 13 customers who made purchases spent a mean of $93 with a standard deviation of $22. Construct and interpret a 99% confidence interval for the true difference between the mean amounts spent by customers while listening to different types of music in the store. Assume that the population standard deviations are the same.

25. A researcher wants to know who reads more, Millenials or GenXers. She surveys 28 Millenials and finds that they read a mean of 2.5 books a month, with a standard deviation of 0.9 books. For the 25 members of Generation X that she surveys, she finds that they read a mean of 2.1 books per month with a standard deviation of 0.8 books. Assuming that the population standard deviations are different, construct and interpret a 90% confidence interval for the true difference between the mean numbers of books read each month by these two generations.

26. A manufacturer of bicycle tires wishes to perform a test of its new tire prototype before putting it into consideration for mass production. They wish to know if there is a significant difference in the lifetime of the new tires versus their standard model. The new tires are given to a group of 15 cyclists and they are able to ride for an average of 2040 miles before needing replacement, with a standard deviation of 22 miles. Another group of 14 cyclists is given standard tires from the company, and they are able to ride on average 1895 miles before needing replacement, with a standard deviation of 20 miles. Construct and interpret the 99% confidence interval for the true difference in mileage between the two tires. Assume that the variances of the tires produced from the same company have the same population standard deviations.