Part B

Question 6

Spend about 25 minutes on this part of the exam.

Percent of Section II grade—25

Directions: Show all your work. Indicate clearly the methods you use, because you will be graded on the correctness of your methods as well as on the accuracy of your results and explanation.

6. Lead, found in some paints, is a neurotoxin that can be especially harmful to the developing brain and nervous system of children. Children frequently put their hands in their mouth after touching painted surfaces, and this is the most common type of exposure to lead.

   A study was conducted to investigate whether there were differences in children's exposure to lead between suburban day-care centers and urban day-care centers in one large city. For this study, researchers used a random sample of 20 children in suburban day-care centers. Ten of these 20 children were randomly selected to play outside; the remaining 10 children played inside. All children had their hands wiped clean before beginning their assigned one-hour play period either outside or inside. After the play period ended, the amount of lead in micrograms (mcg) on each child's dominant hand was recorded.

   The mean amount of lead on the dominant hand for the children playing inside was 3.75 mcg, and the mean amount of lead for the children playing outside was 5.65 mcg. A 95 percent confidence interval for the difference in the mean amount of lead after one hour inside versus one hour outside was calculated to be $(-2.46, -1.34)$.

   A random sample of 18 children in urban day-care centers in the same large city was selected. For this sample, the same process was used, including randomly assigning children to play inside or outside. The data for the amount (in mcg) of lead on each child's dominant hand are shown in the table below.

Urban Day-Care Centers

Inside	6	5	4	4	4.5	5	4.5	3	5
Outside	15	25	18	14	20	13	11	22	20

   (a) Use a 95 percent confidence interval to estimate the difference in the mean amount of lead on a child's dominant hand after an hour of play inside versus an hour of play outside at urban day-care centers in this city. Be sure to interpret your interval.

Question 6

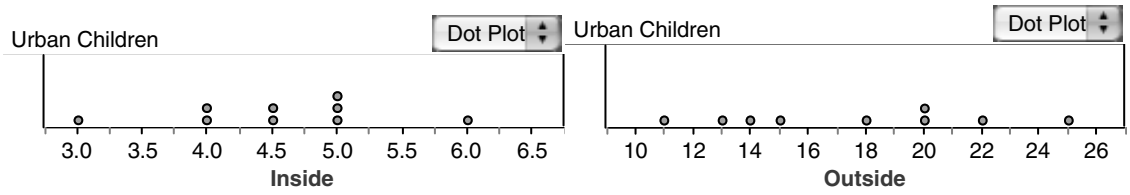
Solution

Part (a):

Step 1: State and check appropriate conditions for two-sample *t*-confidence interval.

State conditions: The two samples are selected randomly and independently from the two populations. The population distributions of the amount of lead on the dominant hand for both groups of children (those who could be sent to play inside and those who could be sent to play outside) are normal.

Check conditions: The procedure described in the stem is equivalent to taking a random sample from the population of children in urban day-care centers who could be assigned to play inside and an independent random sample from the population of children in urban day-care centers who could be assigned to play outside. The symmetry and lack of outliers in the dotplots below indicate that the normal assumption is reasonable for both populations of children.



Step 2: Identify the two-sample *t*-interval (by name or formula) and provide correct mechanics

Identification: Two-sample *t*-confidence interval for the difference of two means

OR

$$\bar{x}_{in} - \bar{x}_{out} \pm t^* \sqrt{\frac{s_{in}^2}{n_{in}} + \frac{s_{out}^2}{n_{out}}}$$

Mechanics: Using the summary statistics

	N	Mean	StDev
Inside	9	4.56	0.846
Outside	9	17.56	4.61

and the conservative $df = \min(n_1 - 1, n_2 - 1) = 8$, the 95% confidence interval for the difference of the two means is:

$$(4.56 - 17.56) \pm 2.306\sqrt{\frac{(0.846)^2}{9} + \frac{(4.61)^2}{9}} \quad \text{or} \quad (-16.60, -9.40) \text{ mcgs.}$$

Question 6 (continued)

OR

Using fractional $df = 8.537$, the 95% C.I. for $(\mu_{in} - \mu_{out})$ is (–16.57, –9.43) mcgs.

Step 3: Interpret the confidence interval in context.

We are 95 percent confident that the difference between the mean amount of lead on the dominant hands of the population of urban day-care children after an hour of play inside and the mean amount of lead on the dominant hands of the population of urban day-care children after an hour of play outside at an urban day-care center is between –16.60 and –9.40 mcgs.

OR

Because this interval does not include zero, we can conclude that there is a significant difference in the mean amount of lead on the hands of the two different groups of urban day-care children after one hour of play. On average, urban day-care children who play outside have higher amounts of lead on their hands.

Part (b)

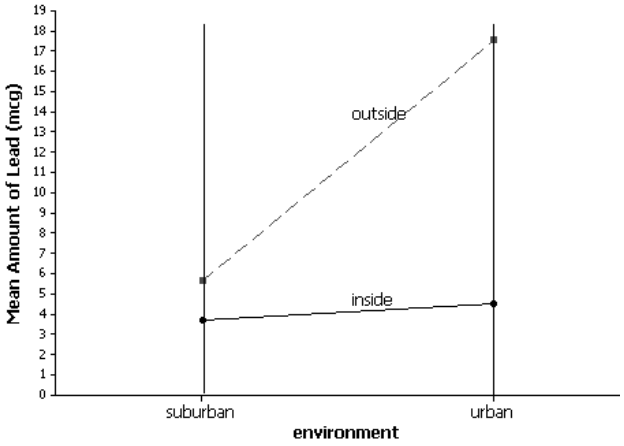


Table of Means

	Suburban	Urban
Inside	3.75	4.56
Outside	5.65	17.56

Question 6 (continued)

Part (c)

Inside/Outside: For both environments (urban and suburban), the mean amount of lead on the dominant hands of children who play outside is higher than the mean amount of lead on the dominant hands of children who play inside. This can be justified by comparing means OR confidence intervals OR interpreting the graph. All four endpoints of the two confidence intervals (inside minus outside) are negative. The graph clearly shows that the line connecting the two "outside" means for the different environments is above the line that connects the "inside" means.

Suburban/Urban: For both settings (inside and outside), the amount of lead on the dominant hand of urban children is higher on average than the amount of lead on the dominant hand of suburban children. This can be justified by comparing means or interpreting the graph: both lines slant upward to the right, which indicates an increase from suburban to urban both for children who played inside and for children who played outside.

Relationship: The magnitude of the difference in the mean amount of lead between children playing inside and children playing outside depends on the environment. Equivalently, the graph shows that the means for the urban environment are much farther apart than the means for the suburban environment.

OR

Whether the children play inside or outside makes a bigger difference in the urban environment than in the suburban environment. This is shown by the graph or the fact that the endpoints for the urban confidence interval are farther away from zero than the corresponding endpoints of the suburban confidence interval (and the intervals do not overlap), indicating that the difference is larger for the urban environment.

Scoring

Parts (a) and (b) are scored as essentially correct (E), partially correct (P), or incorrect (I). Part (c) is divided into two subparts. Each of these subparts is scored as essentially correct (E), partially correct (P), or incorrect (I).

Each of the three steps in part (a) is scored as acceptable or unacceptable.

Part (a) is essentially correct (E) if all three steps are acceptable. A step may be scored as acceptable even if it contains a minor error.

Part (a) is partially correct (P) if two steps are acceptable.

Part (a) is incorrect (I) if at most one step is acceptable.

Notes:

Step 1: Conditions

- A pair of dotplots, stemplots, histograms, normal probability plots, or boxplots may be provided to check the normality assumption.
- If the response uses an unacceptable procedure in Step 2, credit may be given in Step 1 if the check of conditions is consistent with the specified procedure.

Question 6 (continued)

Step 2: Identification of interval and computations

If one of the following procedures is used, Step 2 is scored as unacceptable:
- Paired *t*-procedure; OR
- Separate confidence intervals for inside and outside; OR
- Large-sample *z*-procedure: n_{in} and n_{out} are not large enough to assume normality; OR
- Pooled *t*-confidence interval. The assumption that $\sigma_{in} = \sigma_{out}$ is not reasonable; OR
- Concluding that the sample sizes are too small for inference.

Step 3: Conclusion
- Just interpreting the 95% confidence level is scored as unacceptable.
- If the response uses an unacceptable procedure in Step 2, credit may be given in Step 3 if the conclusion is acceptable for the specified procedure.

Part (b) is scored as essentially correct (E) if:
- The four points and two lines are placed correctly with a correct scale (either a numerical scale on a vertical line or the four means written next to the four points); AND
- The vertical axis is labeled ("lead" or "mcg" is sufficient) OR the two lines are labeled "inside" and "outside."

Part (b) is partially correct (P) if the four points and two lines are placed correctly but either:
- The vertical axis AND the two lines are not labeled but the numerical scale is correct; OR
- At least one label is included AND the numerical scale is incorrect.

Part (b) is incorrect (I) if the four points and two lines are not placed correctly OR there is no numerical scale.

Part (c) contains two parts. Each part is scored as essentially correct (E), partially correct (P), or incorrect (I). The first part (c1) deals with direct comparisons between environments (suburban versus urban) and settings (inside versus outside), where the comparisons must be supported using the data. The second part (c2) deals with the nature of the relationship between the means as setting and environment change.

Part (c1) is scored as essentially correct (E) if the student:
- Makes it clear that outside is greater than inside in both suburban and urban environments; AND
- Makes it clear that urban is greater than suburban in both inside and outside settings; AND
- Justifies one or both comparisons by referencing the graph, the means given in part (b), or the two confidence intervals.

Part (c1) is partially correct (P) if two of the above are included.

Part (c1) is incorrect (I) if at most one of the above is included.