MAT.HS.PT.4.CANSB.A.051

Sample Item ID:	MAT.HS.PT.4.CANSB.A.051
Title:	Packaging Cans
Grade:	HS
Primary Claim:	**Claim 4: Modeling and Data Analysis** Students can analyze complex, real-world scenarios and can construct and use mathematical models to interpret and solve problems.
Secondary Claim(s):	Claim 2: Problem Solving Students can solve a range of complex well-posed problems in pure and applied mathematics, making productive use of knowledge and problem solving strategies. Claim 1: Concepts and Procedures Students can explain and apply mathematical concepts and interpret and carry out mathematical procedures with precision and fluency.
Primary Content Domain:	**Geometry**
Secondary Content Domain(s):	Algebra, Functions, Statistics, and Probability
Assessment Target(s):	4A: Apply mathematics to solve well-posed problems arising in everyday life, society, and the workplace. 4E: Analyze the adequacy of and make improvements to an existing model or develop a mathematical model of a real phenomenon. 4D: Interpret results in the context of a situation. 4G: Identify, analyze, and synthesize relevant external resources to pose or solve problems. 4B: Construct, autonomously, chains of reasoning to justify mathematical models used, interpretations made, and solutions proposed for a complex problem. 2B: Select and use appropriate tools strategically. 1G: Create equations that describe numbers or relationships. 1H: Understand solving equations as a process of reasoning and explain the reasoning. 1L: Interpret functions that arise in applications in terms of a context. 1P: Summarize, represent, and interpret data on a single count or measurement variable.

	1H (Gr 8): Understand and apply the Pythagorean theorem. 1I (Gr 8): Solve real-world and mathematical problems involving volume of cylinders, cones, and spheres.
Standard(s):	A-CED.2, A-CED.4, A-REI.2, F-IF.4, G-GMD.3, G-MG.3, S-ID.1, S-IC.1, 8.G.7, 8.G.9
Mathematical Practice(s):	1, 2, 3, 4, 5, 6
DOK:	4
Item Type:	PT
Score Points:	20
Difficulty:	H
How this task addresses the "sufficient evidence" for this claim:	The student uses concepts of geometry, functions, and statistical analysis to determine appropriate arrangements and measures that will minimize waste and cost. Additionally, the student must provide mathematical justifications to support reasoning.
Target-specific attributes (e.g., accessibility issues):	Accommodations may be necessary for students who have visual challenges.
Stimulus/Source:	http://zunal.com/webquest.php?w=4309 http://math.arizona.edu/~vpiercey/PackingEfficiency.pdf http://www.cancentral.com/howmade.cfm#twopiece http://answers.google.com/answers/threadview/id/601197.html
Notes:	Multiple sessions
Task Overview:	The student assumes the role of consultant to the president of a beverage company. In class and individually, the student completes tasks in which he/she investigates the impact on the amount of space used in a box with different arrangements of the cans in the box. This investigation is done in class using spreadsheets specifically designed to compute measures. Students also investigate this analytically in their individual work. The student further explores minimizing cost to the company by determining a function for this purpose based on given information. Finally, the student provides statistical reasoning to make a valid argument based on data provided.
Teacher preparation / Resource requirements:	Teacher preparation: Up to two school days prior to administration of the task, students must be assigned a prework task that will be used to help their understanding of the objectives of the task itself. Students must have pre-work ready to be shared at the start of the task. Session 1 of the task will start with students being divided into groups of 3 or 4 to complete Part A. Afterwards, results of the group work will be discussed as a class. The remainder of session 1 will include Part B, and should be completed individually. During session 2, Parts C and D should be completed individually.

	Resource requirements: Students will need to access graphing calculator software and statistical software provided in the tasks. Or they will need to be provided with other tools in which they can organize data into a box plot. The tool(s) the students use should allow for finding the minimum value of a function within a set region. Furthermore, spreadsheet software should be available to students in Part C of the task. This part allows students to receive hint(s) if they have difficulty approaching and solving the given problem. Should the student use this option, he/she will receive fewer points for their answer, depending on the number of hints they choose to use.
Teacher Responsibilities During Administration:	Monitor individual student work; provide resources as necessary.
Time Requirements:	One prework assignment is given up to two school days prior to starting this task. The prework will not be scored. Two sessions of the task, including both group work and individual work, will total no more than 120 minutes. All portions of the task will be scored, with the exception of the group work in Part A.

Packaging Cans

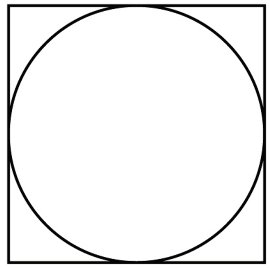
Prework

[Up to two school days prior to starting the performance task, teachers should assign the following work to students. This prework must be brought to class on the day the performance task begins.]

Perform a search to find the dimensions, in centimeters, of a standard-sized soda (pop) can. Identify the radius of the circular base of the can and the height of the can.

radius = __________ cm   height = _________ cm

Imagine a circle fit inside a square so that it touches each side of the square, as shown in this diagram.



The circle has the same radius as the soda can whose dimensions you identified above. Find the area, in square centimeters, inside the square that represents the area outside the circle.

Area = __________ cm^2

Write the formula for the surface area and volume of a right circular cylinder.

Surface Area = ___________________

Volume = ___________________

Packaging Cans

Session 1

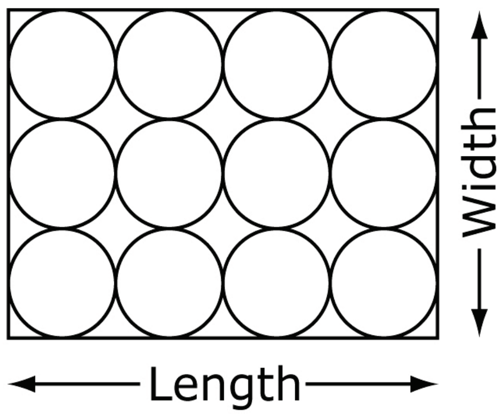
Part A (Group work)

[Session 1 of the task will start with group work. Students will be divided into groups of 3 or 4 and work for about 20 minutes using part of their pre-work assignment to explore the relationships among different ways to stack cans in a box. This group work will not be scored.]

You have been asked to be a consultant for a beverage company. The company president would like you to investigate how soda cans are packaged. Cans are constructed in such a way that they are not truly cylinders, but for the purpose of your investigation, we will assume that they are right circular cylinders.

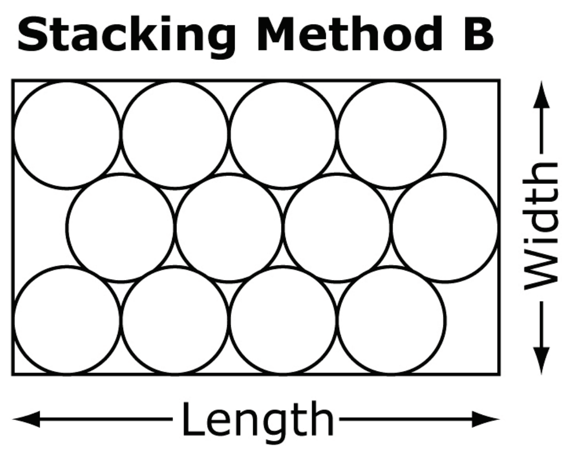
The current boxes used to package soda cans have rectangular bases. The 12 cans in a box are stacked in one layer. The diagram below shows Stacking Method A, a 3-can by 4-can arrangement.

Stacking Method A



With your group, find all possible one-layer stacking arrangements for 12 cans in a rectangular box where the cans touch as shown. Show them in the space below. The number of cans along the length and the width must be factors of 12.

The president of the beverage company shows a preference for a 3-can by 4-can arrangement. The president suggests an alternate way of stacking the 12 cans in a box, using Stacking Method B, shown below.



Use the spreadsheet below to compare the different stacking methods of 12 cans. In the top portion of the spreadsheet, enter appropriate values into the highlighted spaces. The spreadsheet will calculate the parts in the bottom portion based on the values you entered.

[Table presented to students]

Stacking Cans				
	Method A			Method B
Radius of can (cm)				
Number of rows	3			
Cans in each row	4			
Base area of one can				
Base area of 12 cans				
Box length (cm)				
Box width (cm)				
Base area of box (cm^2)				
Area of base NOT covered by cans (cm^2)				
Percent of base area NOT used by cans				

In your groups answer the following:

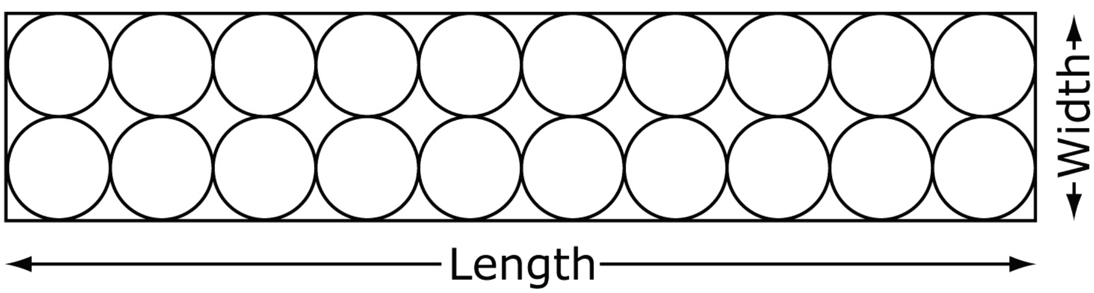
- What are some similarities in the quantities you see in the spreadsheet?
- What are some differences in the quantities?
- What do you think these quantities suggest about the efficiency of the different stacking methods?

Cans in a Box

Part B

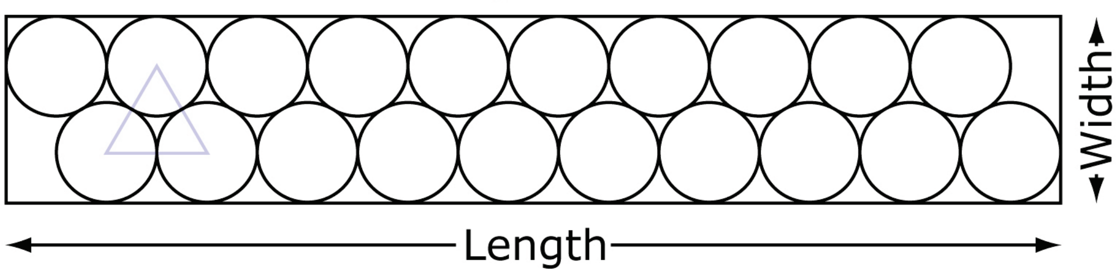
The beverage company is planning to put 20 cans in a box, stacked in one layer. They have asked you to do an analysis to determine the best way to arrange the cans to minimize wasted space and packaging materials. The diagram below represents one arrangement proposed by the company.

Arrangement X



A second arrangement of the 20 cans, shown below, uses a different amount of space in the base of the box.

Arrangement Y



Note: The triangle outlined inside Arrangement Y might help with finding the dimensions of that arrangement.

Answer the following questions about these two arrangements and provide justifications for those answers. For each question, you may use a combination of diagrams, mathematical expressions/equations, and words to justify your response.

1. Which of these two arrangements, X or Y, has less wasted space?

Click on one: X Y

[By clicking on either X or Y, the response will be highlighted.]

Justification:

2. Does it follow that a box whose arrangement has less wasted space also has a smaller surface area?

Click on one: YES NO

[By clicking on either yes or no, the response will be highlighted.]

Justification:

3. Show a third way to arrange the 20 cans that would result in a box that has a smaller surface area than the box proposed by the company, as shown by Arrangement X.

Justification:

Session 2

Size of the Can

Part C

The president of the beverage company wants to minimize the cost involved in the production of standard cans.

1. Calculate the surface area, in square centimeters, and volume, in cubic centimeters, of a standard can that has a radius of 3.3 cm and a height of 12 cm.

Surface Area = ____________________

Volume = ____________________

2. Find the radius and height, in centimeters, of the cylindrical can that would contain the same volume as a standard can but would minimize the surface area. You may use the graphing calculator from the link below in your investigation.

http://www.shodor.org/interactivate/activities/FunctionFlyer/

radius = __________ cm height = _________ cm

Variation: For successively greater deductions in total points possible, student may ask for up to 3 "hints" and receive them in the order shown below.

Hint 1: The formula for the surface area of a cylinder is $S = 2\pi r^2 + 2\pi rh$. The formula for the volume of a cylinder is $V = \pi r^2 h$. Use the volume you calculated for a standard can and the volume formula to solve for the height, *h*. Then use the resulting expression for *h* in the surface area formula to determine a function that can be used to find the radius for the can with the minimum surface area.

Hint 2: The function $y = 2\pi x^2 + \frac{821.08}{x}$ represents the surface area of a cylinder in terms of its radius. Graph this function and find the minimum value of *y*.

Hint 3: An alternative strategy is to estimate the solution by substituting possible values for the radius. You can use the "guess and check" table below. Enter different values for the radius in the highlighted spaces. The table will calculate the values for height and surface area of the can.

Radius (cm)	Height (cm)	Surface Area (cm^2)

3. Would you recommend to the president of the beverage company changing the dimensions of the can based on your results above? How would you convince the president that your recommendation is valid? Justify your answer in the space below.

Is this Unusual?

Part D

You suspect that one of your competitors, “Big-Jump Soda,” is under-filling their cans of soda. You decide that you will purchase a random sample of 30 cans of “Big-Jump,” measure the contents, and draw a conclusion based on your results.

Describe a method for collecting the 30 cans to be used in your random sample.

The following is the amount of soda, in milliliters, of the 30 cans from your sample.

355, 354, 354, 354, 354, 352, 355, 351, 357, 351,
355, 355, 355, 356, 354, 353, 353, 352, 354, 355,
352, 354, 355, 354, 354, 355, 355, 352, 352, 355

Organize your data into a box plot. You may use either of the online tools shown below.

http://www.alcula.com/calculators/statistics/box-plot/

http://www.shodor.org/interactivate/activities/BoxPlot/

The advertised amount of soda in a regular can is 355 ml. Based on the results of your study, do you think that “Big-Jump” is under-filling their cans? Be sure to use statistics and your graph to support your conclusion.

End of Session 2

Sample Top-Score Response:

Part A (Group work; not scored)

Arrangements should be shown for 3 rows of 4 (or 4 rows of 3), 2 rows of 6 (or 6 rows of 2), and 1 row of 12 (or 12 rows of 1).

[Completed table]

Stacking Cans				
	Method A			Method B
Radius of can (cm)	3.3	3.3	3.3	3.3
Number of rows	3	2	1	3
Cans in each row	4	6	12	4
Base area of one can	34.21	34.21	34.21	34.21
Base area of 12 cans	410.54	410.54	410.54	410.54
Box length (cm)	26.4	39.6	79.2	29.70
Box width (cm)	19.8	13.2	6.6	18.03
Base area of box (cm^2)	522.72	522.72	522.72	535.54
Area of base NOT covered by cans (cm^2)	112.18	112.18	112.18	124.99
Percent of base area NOT used by cans	21.46%	21.46%	21.46%	23.34%

All variations of both methods have the same soda can radius, and as a result, the same base area of one and 12 cans. All variations in method A have the same base area of the box, and as a result, the same area and percent of the base not covered by cans.

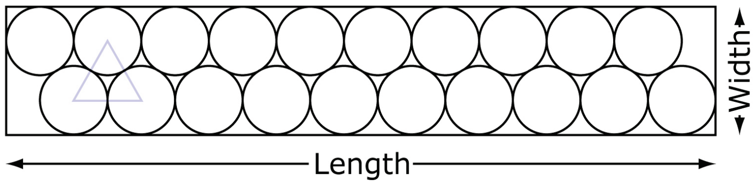
Differences exist between methods A and B in the dimensions of the box, and as a result, the areas of the base of each box. Since the areas of the bases of both boxes are different, the area and percent of the bases' areas not covered by cans are also different.

The different values for both methods A and B suggest that different arrangements of cans cause box sizes to be different. And different-sized boxes, each containing the same number of cans, are going to have different amounts of wasted space.

Part B

1. For arrangement X, the base of the box has length $20r$ and width $4r$, where r is the length of the radius of a can. Therefore, the area of the base of the box is $80r^2$. Since the total area of the base of the cans in this arrangement is $20\pi r^2$, then the percent of the base of the box covered by the cans in this arrangement is $\frac{20\pi r^2}{80r^2} \approx .7854$ or 78.54%.

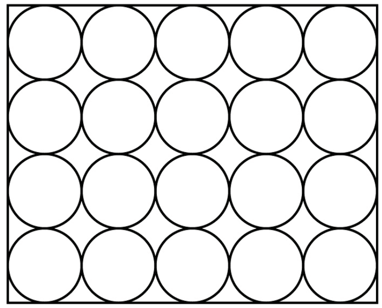
Arrangement Y



For arrangement Y, the length is $21r$. The height of the triangle can be found by using the Pythagorean theorem in which the length of the hypotenuse is $2r$ and the length of the other leg is r. Therefore, the height of the triangle is $\sqrt{(2r)^2 - r^2}$ or $\sqrt{3}r$. Thus, the width of this arrangement is $2r + \sqrt{3}r$. The area of the base of the box for arrangement Y is then $42r^2 + 21\sqrt{3}r^2$. The base of the cans in this arrangement has area $20\pi r^2$. As a result, the percent of the base of the box that is covered by the cans in this arrangement is $\frac{20\pi r^2}{42r^2 + 21\sqrt{3}r^2} \approx 80.17\%$. Since arrangement Y uses more space in the base of the box than arrangement X, arrangement Y has less wasted space than arrangement X, proposed by the company.

2. The dimensions of the box with arrangement X are $20r$ by $4r$ by 12. Since $r = 3.3$, the dimensions are 66 by 13.2 by 12. So, the surface area of the box with arrangement X is $2(66 \times 13.2 + 66 \times 12 + 13.2 \times 12) = 3643.2 \text{ cm}^2$. The dimensions of the box with arrangement Y are $21r$ by $2r + \sqrt{3}r$ by 12. Since $r = 3.3$, the dimensions are 69.3 by 12.3 by 12. So, the surface area of the box with arrangement Y is $2(69.3 \times 12.3 + 69.3 \times 12 + 12.3 \times 12) = 3663.18 \text{ cm}^2$. Arrangement X has a smaller surface area but more wasted space. Therefore, it does not follow that a box with less wasted space will have a smaller surface area.

3. One example, shown here, includes a 5-can by 4-can arrangement with dimensions 33 by 26.4 by 12. The surface area of this box would be $2(33 \times 26.4 + 33 \times 12 + 26.4 \times 12) = 3{,}168 \text{ cm}^2$.



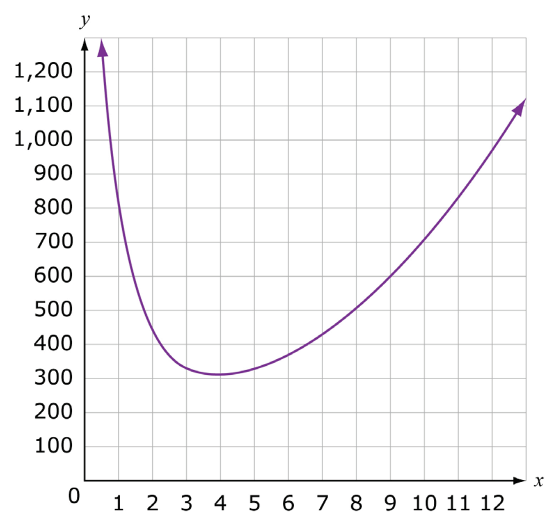
Part C

1. For a standard can with the given dimensions, the surface area is approximately $2\pi(3.3)(12)+2\pi r^2 = 317.24\text{ cm}^2$. The volume is approximately $\pi(3.3)^2(12) = 410.54\text{ cm}^3$.

2. Since the desired volume of the can is 410.54 cm^3, the formula for the surface area of the can may be used to determine the function in the following manner:

$$\left.\begin{array}{l} V = 410.54 = \pi r^2 h \Rightarrow h = \dfrac{410.54}{\pi r^2} \\ SA = 2\pi r^2 + 2\pi rh \end{array}\right\} \Rightarrow SA = 2\pi r^2 + 2\pi r\dfrac{410.54}{\pi r^2} = 2\pi r^2 + \dfrac{821.08}{r}$$

Using a graphing tool, the function can be graphed for the positive values of *x*, since the radius of the can must be positive. The graphing tool can be used to find the minimum of the graph for positive *x*-values. The minimum occurs where the radius is approximately 4.03 centimeters and the height would then be equivalent to $\dfrac{410.54}{\pi(4.03^2)} \approx 8.05$ centimeters.



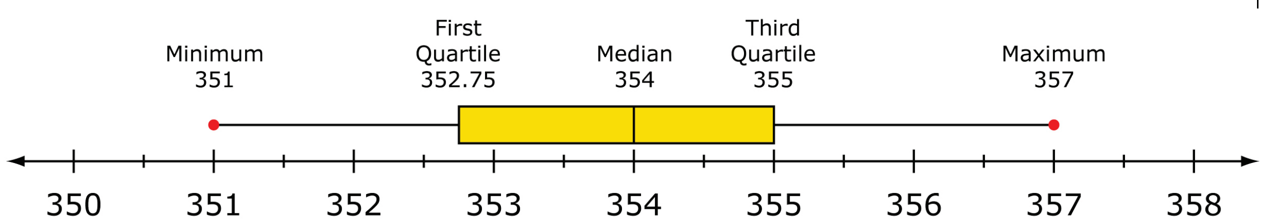
[Sample table from hint #3]

Radius (cm)	Height (cm)	Surface Area (cm^2)
2	32.67	435.67
2.5	20.91	367.70
3	14.52	330.24
3.5	10.67	311.56
4	8.17	305.80
4.2	7.41	306.33
4.4	6.75	308.25
4.6	6.18	311.45
4.8	5.67	315.82
5	5.23	321.30

3. There are many valid responses, and points will be awarded based on the meaningful justification provided. The response should include mathematically supported reasons that benefit the company and not student preference. The surface areas of the standard-sized can and the can with minimum surface area should be compared. The student should take into account that the can with the smaller surface area has new dimensions. This will impact the amount of wasted space inside packaged boxes, and will also affect the surface area of the box.

Part D

1. There are many different possible responses. The method described must take into account that the sample should be random. For example, the 30 cans should not all come from the same store or even from the same region, town, or state.



2. Based on the data and box plot for the data, it appears that the company is under-filling their soda cans. The graph shows a median of 354 ml. This indicates that more than half of the cans have less than the advertised amount of soda inside.

Scoring Notes:

Each part of the task is evaluated individually. The total number of points is determined by adding the points assigned for each part (except *Part A*).

Scoring Rubric:

Part A Not scored. While it is desirable that the student followed the directions to create a picture that uses at least one of each colored shape with no overlap, the resulting picture has no measureable value in terms of fractional sense and understanding areas with respect to shapes.

Scoring Rubric for ***Part B*** Question 1: Responses to this item will receive 0-3 points, based on the following:

3 points: The student shows a thorough understanding of how to find the dimensions of each box in arrangements X and Y and the amount of wasted space in both boxes. The student knows to and correctly applies the Pythagorean theorem to find the height of the triangle shown on arrangement Y to determine the dimensions of that box. The student fully understands theprocess for comparing the space used in both arrangements by correctly calculating and comparing the spaces used: 78.54% and 80.17%. The student correctly identifies arrangement Y as having less wasted space.

2 points: The student shows some understanding of how to find the dimensions of each box in arrangements X and Y and the amount of wasted space in both boxes. The student applies the Pythagorean theorem to help determine the dimensions of the box in arrangement Y, but makes an error in calculating one of the dimensions of either box or the area of either box. The student understands the process for calculating and comparing the amount of wasted space in the boxes for both arrangements.

1 point: The student shows partial understanding of how to find the dimensions of each box in arrangements X and Y and the amount of wasted space in both boxes. The student either does not apply the Pythagorean theorem to determine a dimension of the box in arrangement Y, or the student makes more than one error in calculating the dimensions or areas of either arrangement's bases. The student understands the process for comparing the amount of wasted space in the boxes for both arrangements. **OR** The student understands the process for calculating the amount of wasted space inside each box but makes some errors calculating the dimensions of each box, the areas of each base, and/or amount of space used inside the boxes.

0 points: The student shows inconsistent understanding of how to find the dimensions of each box in arrangements X and Y and the amount of wasted space in both boxes. The student does not correctly find the dimensions of either box and the student does not correctly calculate the amount of wasted space in each box.

Part B, Question 2: Responses to this item will receive 0-2 points, based on the following:

2 points: The student shows a thorough understanding of how to apply the concepts of area and surface area to draw conclusions about the relationship between the two measures. The student accurately calculates the surface areas of both boxes in arrangements X and Y and correctly compares these surface areas to the amount of wasted space in each box. The student clearly shows or explains why a box with less wasted space does not necessarily have a smaller surface area.

1 point: The student shows partial understanding of how to apply the concepts of area and surface area to draw conclusions about the relationship between the two measures. The student makes a calculation error in determining the surface area of one or both boxes but is still able to draw a correct conclusion about the relationship between surface area and the amount of wasted space inside each box. **OR** The student calculates the correct surface area of both boxes but draws an incorrect conclusion about the relationship between surface area and the amount of wasted space inside each box.

0 points: The student shows inconsistent understanding of how to apply the concepts of area and surface area to draw conclusions about the relationship between the two measures. The student does not identify the correct surface area of either box and does not show an understanding of the relationship between the surface areas of each box and the amount of wasted space inside each box.

Part B, Question 3: Responses to this item will receive 0-2 points, based on the following:

2 points: The student shows a thorough understanding of how to apply the concepts of surface area to identify an arrangement with a smaller surface area than a given arrangement. The student provides an example of a box with a different arrangement than the one proposed by the company, correctly calculates the surface area of the different box, and shows that the surface area is less than the surface area of the box proposed by the company.

1 point: The student shows partial understanding of how to apply the concepts of surface area to identify an arrangement with a smaller surface area than a given arrangement. The student provides an example of a box with a different arrangement than the one proposed by the company, but makes a minor error calculating its surface area.

0 points: The student shows inconsistent understanding of how to apply the concepts of surface area to identify an arrangement with a smaller surface area than a given arrangement. The student shows an arrangement for a box that either does not have a smaller surface area than the one proposed by the company or the student does not understand how to calculate or compare the surface areas of both boxes.

Part C
Question 1: Correct responses for the surface area and volume will each receive 1 point and are scored independently.

Surface area: 317.24 cm^2
Volume: 410.54 cm^3

Part C, Question 2: Responses to this item will receive 0-5 points, based on the following:

5 points: The student shows a thorough understanding of how to use algebraic and geometric reasoning to find the dimensions of a cylinder with a given volume and minimized surface area. The student uses the relationship between the volume and surface area of a cylinder to determine a correct function for the surface area in terms of the radius. The student graphs and interprets this function correctly to identify its minimum *x*-value. The student identifies the correct radius, 4.03 cm, and calculates the correct height, 8.05 cm, of the cylinder with this minimum surface area. All student calculations and interpretations are performed without using any available hints.

4 points: The student shows a strong understanding of how to use algebraic and geometric reasoning to find the dimensions of a cylinder with a given volume and minimized surface area. The student uses the relationship between the volume and surface area of a cylinder to determine a correct function for the surface area in terms of the radius. The student graphs this function but does not interpret it correctly to find the correct radius, but calculates a correct height using the incorrect radius. Or the student graphs and interprets the graph to identify the correct radius but calculates the incorrect height. All student calculations and interpretations are performed without using any available hints.

3 points: The student shows an average understanding of how to use algebraic and geometric reasoning to find the dimensions of a cylinder with a given volume and minimized surface area. The student uses the first hint describing the relationship between the volume and surface area of a cylinder to determine a correct function for the surface area in terms of the radius. The student graphs and interprets this function correctly to identify its minimum *x*-value. The student identifies the correct radius and height of the cylinder with this minimum surface area.

2 points: The student shows partial understanding of how to use algebraic and geometric reasoning to find the dimensions of a cylinder with a given volume and minimized surface area. The student uses the first two hints describing the relationship between the volume and surface area of a cylinder and giving the student the function for the surface area in terms of the radius. The student graphs and interprets this function correctly to identify its minimum *x*-value. The student identifies the correct radius and height of the cylinder with this minimum surface area. **OR** The student uses the first hint describing the relationship between the volume and surface area of a cylinder to determine a correct function for the surface area in terms of the radius. The student graphs and interprets this function incorrectly. As a result, the student identifies the incorrect radius and incorrect height of the cylinder with this minimum surface area. **OR** The student uses the first hint describing the relationship between the volume and surface area of a cylinder but makes a minor error in determining the function for the surface area in terms of the radius. The student graphs and interprets this function correctly to identify a minimum *x*-value. The student identifies an appropriate radius and height based on the incorrect function graph.

1 point: The student shows limited understanding of how to use algebraic and geometric reasoning to find the dimensions of a cylinder with a given volume and minimized surface area. The student uses all three hints to help determine the minimum surface area for the cylinder with the given volume. The student manipulates the spreadsheet to determine the correct value of the radius and calculates the correct height of the cylinder. **OR** The student uses the first two hints describing the relationship between the volume and surface area of a cylinder and giving the student the function for the surface area in terms of the radius. The student graphs this function correctly but identifies an incorrect, but close (within 0.5 cm), minimum value for the radius. The student identifies the correct height based on the incorrect radius.

0 points: The student shows inconsistent understanding of how to use algebraic and geometric reasoning to find the dimensions of a cylinder with a given volume and minimized surface area. The student uses all three hints to help determine the minimum surface area for the cylinder with the given volume. The student incorrectly manipulates the spreadsheet to determine an incorrect value of the radius and calculates an incorrect height of the cylinder. **OR** The student uses no hints and cannot determine the correct function for the surface area in terms of the radius. The student either doesn’t graph the flawed function correctly or misinterprets how to find its minimum value. The student does not identify the correct radius or height. **OR** The student uses one or two hints but does not graph or interpret the function correctly to find its minimum value. The student does not identify the correct radius or height.

Part C, Question 3: Responses to this item will receive 0-2 points, based on the following:

2 points: The student shows a thorough understanding of how to justify and support a valid recommendation using mathematical reasoning. The student provides a complete and accurate justification as to whether the standard can size should be changed. The student supports his or her reasoning using both the surface area and the amount of wasted space inside the packaging for both can sizes.

1 point: The student shows partial understanding of how to justify and support a valid recommendation using mathematical reasoning. The student provides an incomplete or partially accurate justification as to whether the standard can size should be changed. The student supports his or her reasoning using either the surface area or the amount of wasted space inside the packaging for both can sizes.

0 points: The student shows an inconsistent understanding of how to justify and support a valid recommendation using mathematical reasoning. The student provides an incomplete and inaccurate justification as to whether the standard can size should be changed.

Scoring Rubric for ***Part D***

Part D, Question 1: Responses to this item will receive 0-1 point, based on the following:

1 point: The student shows a thorough understanding of how to describe a method for collecting data to be used in a random sample. The student provides a reasonable explanation to indicate that the data collected would be random.

0 points: The student shows an inconsistent understanding of how to describe a method for collecting data to be used in a random sample. The student provides an explanation that does not indicate an understanding of what a random sample is.

Part D, Question 2: Responses to this item will receive 0-1 point, based on the following:

1 point: The student shows a thorough understanding of how to use an online graphing utility and given data to create a box plot. The output of the box plot is accurate.

0 points: The student shows an inconsistent understanding of how to use an online graphing utility and given data to create a box plot. The output of the box plot is missing, incomplete, or inaccurate.

Part D, Question 3: Responses to this item will receive 0-2 points, based on the following:

2 points: The student shows a thorough understanding of how to justify and support a conjecture using mathematical reasoning. The student provides a complete and accurate justification as to whether the other beverage company is under-filling its cans. The student supports his or her reasoning using the box plot and the accompanying statistics from the box plot.

1 point: The student shows partial understanding of how to justify and support a conjecture using mathematical reasoning. The student provides an incomplete or partially accurate justification as to whether the other beverage company is under-filling its cans. The student supports his or her reasoning using minimal statistics from the box plot.

0 points: The student shows an inconsistent understanding of how to justify and support a conjecture using mathematical reasoning. The student provides an incomplete and inaccurate justification as to whether the other beverage company is under-filling its cans.