Math-in-CTE Lesson Plan–Agriculture & Construction

Lesson Title: Calculate Board Feet and Material Costs	Lesson #2
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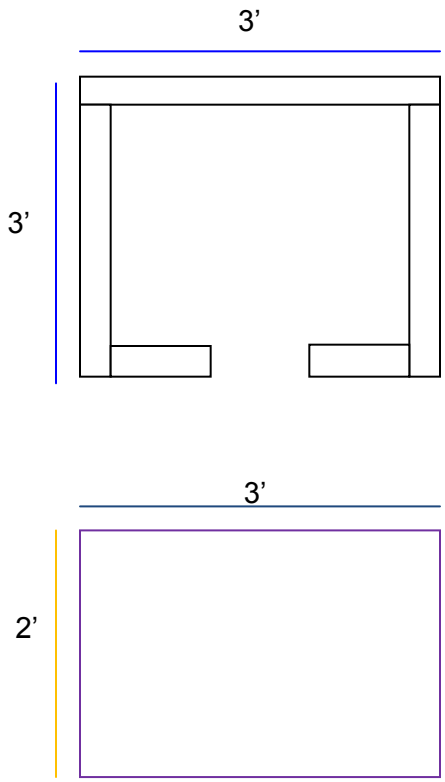
Occupational Area: Agriculture & Industrial Technology
CTE Concept: Calculate board feet
Math Concept: Use algebraic expressions to solve and substitute variables.

Lesson Objectives:	At the conclusion of this lesson, students will be able to: 1. Determine length, width, and thickness of lumber. 2. Calculate board feet needed for a specific project. 3. Calculate the cost of a project.
Common Core State Standards:	CC.9-12.GMD.2 (volume formulas–geometry) CC.9-12.G.MG.2 (modeling area & volume)
Supplies Needed:	1. Writing utensil 2. Rulers and/or tape measures 3. Calculator 4. Chalk or dry erase board

THE “7 ELEMENTS”	TEACHER NOTES (and answer key)
1. Introduce the CTE lesson. **How many of you have played with Lego’s? How many Lego’s do you need to build a castle? How big is that castle?** There are many variables when making a castle out of Lego’s. How large and elaborate will it be? How thick are the walls and ceiling? What is the size of each lego? You may use hundreds or thousands of Lego pieces while another person only uses a few dozen! Building a real structure can be very similar to building a castle with Lego’s except it costs much more! For that reason, we must be able to calculate board feet. Board feet is a lumber measurement. First, we need to figure out the structure and determine its size. Next, we need to know the size of each building material utilized. For instance, 2 × 4’s, 2 × 6’s, plywood, etc. As we have previously discussed, lumber is defined by its nominal size and not its actual size. For example, a 2 × 4” is actually 1½ × 3½”. The equation for calculating board feet is: (length × width × thickness) ÷ 144in.	Lesson would take 2-3 days Make slides or print out pictures of two Lego structures to compare and contrast Give one student a 2 × 4” and 2 × 6” and a ruler. Have them measure and give the actual size. Remind students that lumber does not always come in a nominal size. Have students list lumber sizes both rough and actual

2. Assess students' math awareness as it relates to the CTE lesson. We have already discussed how to read a measuring tape. Are there any questions related to fractions or decimals? How do you find the **volume** of an object? **Box:** L × W × H or L × W × T How do you find the **area** of an object? What is one board foot (BF)? 1 ft. long × 1 ft. wide × 1 inch thick Does the amount of BF affect the cost? What variables might you have when ordering lumber? When calculating board feet, how would you divide parts?	Discuss connections between this lesson in CTE and the content of a math course. Provide students several visual examples to show–lumber, plywood, veneer, timber, etc. Give each student a ruler and piece of lumber. First measure the actual size. Then ask: What is the nominal size you would ask for in a lumberyard or home improvement store? Describe examples of simple woodworking projects that require the one to calculate board feet.

3. Work through the math example embedded in the CTE lesson. How many of you have a pet dog? If not, imagine a dog you might like to have. Since we live in the midwest we have a variety of weather. To make sure our dog can find shelter on a hot summer day or rainy spring, we'll construct a simple doghouse. Focus only on the lumber for the exterior, specifically the walls. We'll determine other parts later. We'll use ¾" plywood for the exterior walls. The house will be 3' × 3' with a 1' wide opening for the door. The walls will be 2' tall. Let's plug the variables into the equation. (36 × 24 × .75) ÷ 144 × 3 = 13.5 (24 × 24 × .75) ÷ 144 = 3 ---------- BF = 16.5 cu.ft	**Sketch** a picture on the board and encourage students to do the same on notebook paper.  *Remember there are 3 similar walls and 1 different wall (the door side) *Remember to include the thickness of the board to calculate BF. All answers must have a lable that defines the number; in this case it would be board feet (BF)

4. **Work through *related, contextual* math-in-CTE examples.**

Let's say you like to workout for your health or as an activity. You decide to make a **'jumpbox'** so you can train at home. You decide to make the box either 1½' or 2½' tall (height). The top of the box will be exactly 2' × 2'. You will use ½" plywood to construct the 'jumpbox.'

There is no board for the bottom of the box, just 4 sides and a top. Go ahead and begin! Show all your work.

(H × W × L) ÷ 144 = Board Feet (BF)

Example 1: 1½' tall box

<u>Sides</u>

(18 × 24 × .5) ÷ 144 = 1.5
× 4

= 6

<u>Top</u>

(24 x 24 x .5) ÷ 144 = 2
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6 + 2 = 8.0 BF

Example 2: 2½' tall box

<u>Sides</u>

(30 × 24 × .5) ÷ 144 = 2.5
× 4

= 10

<u>Top</u>

(24 × 24 × .5) ÷ 144 = 2
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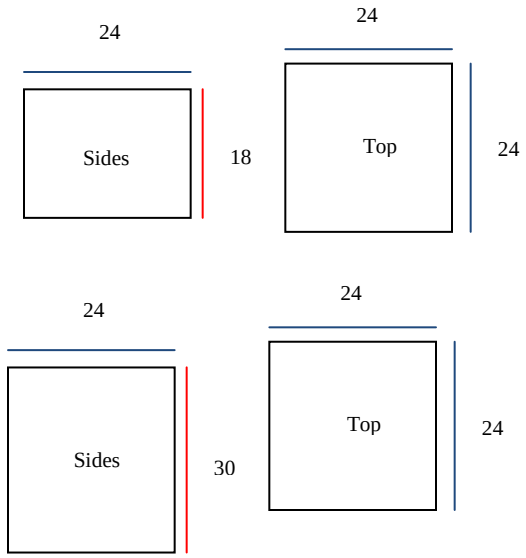
10 + 2 = 12.0 BF

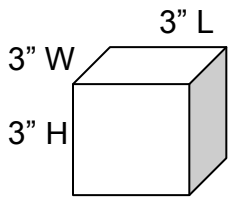
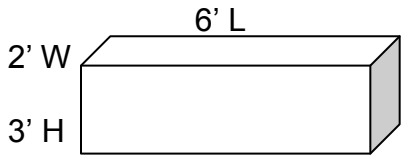
Walk around the classroom and help guide students through any issues. As much as possible guide them through questioning so students learn to answer their own questions.

Require students to show each step of the problem solving process.

As students finish the problems, begin a discussion to ensure everyone understands the process. Have a few students volunteer to complete their calculations at the board.

Finally, cover their work. Cover each problem in its entirity.



5. Work through the *traditional math* examples.	Explain the importance of math and how it ties in everywhere. Most students will be familiar with these problems in a math class and might not associate it with a CTE course. Solve a few simple volume problems that are similar to that of solving for BF.
Example 1: The Cube Let's think about a similar problem you would find in your math class. You will see how simple this truly is! What figure is this?  Cube How is the **volume** of a cube calculated? **Volume = H × W × L (or V= hwl)** We use the term '**thickness'** for lumber but thickness is equal to **height**. Volume = 3" x 3" x 3" = 27 cu. in.	**Example 1: The Cube** A cube is a square with all three sides being equal. Each face is a square.
Example 2: The Cuboid Determine the volume of this figure.  **Volume = height × width × length** 3' × 2' × 6' = 36 cu. ft.	**Example 2: The Cuboid** This cube is a **rectangular box-shaped object with 6 flat sides and all angles are right angles**. All of its faces are rectangles. It is also called a rectangular prism. Examples: a facial tissue box, a tool chest, a shoe box, etc.

6. Students demonstrate their understanding. **Example 1: The Shelf** We are now going to make an imaginary woodworking project–a shelf. The shelf will be make up of ½-, ¾-, and 1-inch thick pieces of poplar. We are going to solve for the amount of wood needed for a class of 30 and the cost associated with that. The **two brackets** are 1-inch thick × 10-inches wide × 10-inches long. The **shelf** will be made of ¾-inch wood. and be 10” × 24”. The **divider** will be ½-inch thick and 2-inches long × 24-inches wide. **Cost of poplar per 1 BF:** ½”.....$1.29 ¾”.....$1.59 1” .....$1.89 10 × 10” × 2 @ 1” 10 × 24” × 1 @ ¾” 2 × 24 × 1 @ ½” (10 × 10 × 1) ÷ 144 = 0.694 × 2 = 1.388 = 1.4 (10 × 24 × .75) ÷ 144 = 1.25 (2 × 24 × .50) ÷ 144 = 0.17 --------- Total 2.82 BF × 30 students --------- Class total = 84.6 BF	**Example 1: The Shelf** Let’s discuss another problem in more depth. This time we are going to use a series of lumber sizes. We are also going to add cost to each. Spend the next few minutes solving the following problem. You should have all the needed material to complete it. I will be walking around to help those who are having difficulties. STEPS: 1. Write down all given information. 2. Calculate BF for each piece of lumber 3. Calculate total BF needed/ individual project. 4. Calculate total BF/class of 30. 5. Calculate total cost/indiv. project 6. Calculate total cost/30 projects 7. Solve for each individual piece of lumber based on thickness 8. Determine the total number of BF needed for the class (10 × 10 × 1) ÷144 = 0.694 × 2 = 1.388 = 1.4 (10 × 24 × .75) ÷ 144 = 1.25 (2 × 24 × .50) ÷ 144 = 0.17 --------- Total 2.82 BF x 30 students --------- Class total = 84.6 BF

1" poplar: (10 × 10 × 1) ÷ 144 = 0.694 × 2 = 1.388 = 1.4 × $1.89 = $2.65 **¾" poplar:** (10 × 24 × .75) ÷ 144 = 1.25 × $1.59 = $1.99 **½" poplar:** (2 × 24 × .50) ÷ 144 = 0.17 × $1.29 = $0.22 Totals: $2.65 + $1.99 + $0.22 = $4.86/project × 30 students --------- Class total cost = $145.80	9. Calculate the cost associated with each piece of lumber per thickness for an individual project 10. Total the costs for all the lumber needed for one project 11. Find the total cost of lumber for a class of 30 students **1" poplar:** (10 × 10 × 1) ÷ 144 = 0.694 × 2 = 1.388 = 1.4 × $1.89 = $2.65 **¾" poplar:** (10 × 24 × .75) ÷ 144 = 1.25 × $1.59 = $1.99 **½" poplar:** (2 × 24 × .50) ÷ 144 = 0.17 × $1.29 = $0.22 Totals: $2.65 + $1.99 + $0.22 = $4.86/project × 30 students --------- Class total cost = $145.80
Example 2: Individual Project Let's check for understanding. Each of you will create a woodworking project of your own choosing. First, you will need to select the type of lumber and its thickness. How much will you need? What is the cost? **Requirements:** • Sketch a simple picture of the project. • Use two different thicknesses of wood. • Dimensions will vary–3 sizes minimum. • Calculate a cost for each piece of wood. Let's cover a few examples – This will be due at the beginning of next class.	**Example 2: Individual Project** Explain the importance of students being able to be creative and calculate their own problems. Therefore, they can complete these problems on their own. Give each student the parameters of the project and let them begin to work. Monitor the students' work. Give examples as students work to check for accuracy. Assign the rest for homework.

7. Formal assessment. **Quiz items and/or problems on final exam for semester course:** ✓ Calculate board feet for each of the following items: 1 piece 10” × 10’ × 1” = _____ BF 1 piece 8” × 6’ × 2” = _____ BF 2 pieces 6” × 6” × ½” = _____ BF 1 piece 1’ × 1’ × 1” = _____ BF ✓ Calculate board feet and material costs of a project with the following parts, if lumber costs $0.60 per board foot. BF Cost 2 sides, each 6” × 18” × 1” _____ _____ 2 ends, each 6” × 10” × 1” _____ _____ 1 bottom, 10 × 16½” × 1” _____ _____	Use these math problems on a quiz or test. Others can be added. Have students show all their work for full credit.