

Lesson 3: Using Plywood to Make Shims

PREREQUISITE ASSUMPTIONS

Before beginning this lesson, students should

- Already have assigned groups - make sure at least one mathematically advanced student is in each group
- Have access to a construction calculator
- Have a copy of the textbook

From Unit 1-Use of Scientific Calculator

A. Perform basic mathematical operations

- A.9. you recognize implicit grouping symbols (fraction bar, radical symbol, etc) in performing calculations
- A.10. you use implicit grouping symbols (fraction bar, radical symbol, etc) in performing calculations
- A.11. you use a scientific calculator to compute expressions that involve addition, subtraction, multiplication, division, exponentiation to powers of 2 and 3 or combinations of these according to the standard order of operation rules

B. Apply basic mathematical operations in solving word problems

- B.1. you translate a verbally stated problem into performing an equivalent computation
- B.2. you interpret the computed answer to a word problem
- B.3. you check the reasonableness of a computed answer to a word problem

From Unit 2- Fractions

A. Perform basic mathematical operations with fractions with construction-friendly denominators

- A.4. you reduce fractions to lowest terms

B. Use fractions in solving word problems

- A.5. you perform multiplication, division, addition, subtraction, or combinations of these operations with fractions according to the standard order of operations using a calculator

Unit 3. Decimal Fractions

A. Perform basic mathematical operations with decimal numbers

- A.1. you recognize fraction names for 0.25, 0.5 and 0.75
- A.8. you use a scientific calculator to compute expressions that involve addition, subtraction, multiplication, division, exponentiation to powers of 2 and 3, square root taking or combinations of these with decimal numbers according to the standard order of operations

Unit 5. Measurement

A. Perform calculations with quantities having units of measure: inches, inches squared, inches cubed, feet, feet squared and feet cubed only.

- A.1. you perform addition, subtraction, multiplication, division, exponentiation to powers of 2 and 3, square root taking or combinations of these operations for quantities expressed as measurements
- A.2. you expresses the answer with the appropriate units
- A.3. you use a scientific calculator to compute the answer to problems involving measured quantities

Notes to Self

- One thing I want to do during this lesson

Make sure every student in each group is engaged

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Make sure students who do not come into the problem knowing how to multiply and divide fractions are asking for help from more mathematically advanced students in their group

- One thing I want to pay attention to in my students' thinking...
- One connection or idea I want to remember is ...

Suggested Timeline

Duration	Activity (Indicate question number)	Suggested Structure (Indicate group, whole class or individual work)
15 minutes	Question 1-7	Groups
10 minutes	Discussion on 1-7	Whole Class
10 minutes	Questions 8 – 9 and extension	Groups
10 minutes	Discussion on 8 – 9 and extension	Whole Class
15 minutes	Calculator Practice 11 - 18	Groups
10 minutes	Calculator Review 11 - 18	Whole Class
5 minutes	Making Connections	

SPECIFIC OBJECTIVES

Use multiplication and division of fractions, whole numbers and mixed numbers, calculators and accurate tape measure skills to find products and quotients of materials' measurements.

By the end of this lesson you will understand...

- How to multiply fractions, whole numbers and mixed numbers on the calculator
- How to divide fractions, whole numbers and mixed numbers on the calculator
- There are at least two ways to multiply and divide fractions, whole numbers and mixed numbers

By the end of this lesson you will be able to...

- Correctly multiply fractions, whole numbers and mixed numbers on the calculator
- Correctly divide fractions, whole numbers and mixed numbers on the calculator

Each group of 3 students is given 7 small rectangles of $\frac{3}{8}$ " plywood that can be easily stacked.

Problem Situation #1: Using plywood for shims

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Sometimes you will use pieces of plywood to raise (or shim) a piece of furniture, a shed or wall. In this activity, you'll be figuring out how many of these shims you need to level a shed that is sitting on very sloped driveway.

Duration	Activity (Indicate question number)	Suggested Structure (Indicate group, whole class or individual work)
15 minutes work 10 minutes discuss	Question 1-7	Groups work Whole class discussion
<p>Notes: The point of the first problem situation is to give the students another chance at measuring fractions and let them use their calculator to multiply fractions. It is again critical that students work with each other in their group to get help. Some students will know how to use the calculator, and some won't. Encourage students to help each other.</p> <p>During this set of problems, circulate among groups making sure everyone is engaged in question #3...make sure no one is using fraction addition or simply adding the fractions in their head...ask a couple of students whose work indicates different procedures to post their work on the board after their group has finished question #7 while other groups are still working.</p> <p>Show at least two methods, one of which uses the construction master calculator. Note the / key and the inches unit that pops up when you use it.</p>		

1. Each student, take a piece of plywood in your hand and estimate the thickness of the plywood. Share your estimate with your group and work together to decide the thickness you think the plywood is. Write the estimate below (include units!).

Answer: $\frac{3}{8}$ "

Anyone that has worked with plywood recognizes $\frac{3}{8}$ " thick. Those that haven't, may still be able to reason it out because they likely have a 'common sense' feel for $\frac{1}{4}$ " and $\frac{1}{2}$ " thick. This problem allows students to practice 'perceptual' estimating, and recognizing how experience can help improve their estimation skills.

2. Now take out your tape measure and verify that your thickness estimate is correct/close. Write down your measured value (include units) and verify that everyone in your group got the same number.

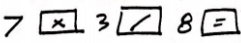
Answer: $\frac{3}{8}$ "

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3. You think that maybe 7 stacked pieces of plywood (that you have on the table) would give you the right thickness of shim for the shed. **Without using addition**, calculate the thickness of 7 stacked pieces of the plywood. Feel free to either use a calculator or your existing fractions skills. Show work or calculator keystrokes here and write your answer with units.

Answer: 2 3/8"

$7/1 \times 3/8 = 21/8 \rightarrow 2 \frac{5}{8}"$

Be sure to demonstrate the calculation on the calculator: 

Write out with boxes on the board or in the notes. Point out that when the students hit the '/' button, the word 'inch' automatically pops up on the calculator.

$3 / 8 " \times 7 = 2 \frac{3}{8} "$

4. If you finish before the others in your group, work with them until everyone in the group has finished problem #3.
5. Now, on your own, measure the total thickness of the stack of 7 pieces of plywood. Write the measurement in the space below.

Total Measured Thickness	
--------------------------	--

6. Compare your measured thickness in #5 with that of your group mates. Does it match? If not, work together to determine the correct total measured thickness. Update your answer in #5 if necessary.
7. Compare your measured thickness in #5 with your calculated thickness in #3. Does it match? Why or why not?

Ideally, the measured thickness should match. However, plywood isn't exactly 3/8" thick... it is very slightly under that amount. So, measuring the stack of 7 pieces, students might end up with something 1/16" thinner than their measurements.

Duration	Activity (Indicate question number)	Suggested Structure (Indicate group, whole class or individual work)
10 minutes work 10 minutes discuss	Question 8 and 9	Groups work Whole class discussion
Notes: The point of the first problem situation is to give the students a chance to do fraction division.		

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Some might use other strategies (which is ok!). Demonstrating the division calculator steps on the Doc Cam is an important part of the class discussion on Question #8.

One important note here is that the calculator will give the answer to #8 as a decimal and, if they try to force the calculator to convert it to a fraction, it won't do $\frac{2}{3}$ because the construction master calculator only makes fractions with denominators of 2, 4, 8 or 16 (can change settings for it to also do 32 and 64). So, they need to figure out how thick of a sheet is 0.6667 of $\frac{3}{8}$ " sheet. So, the idea that they need $\frac{2}{3}$ of a $\frac{3}{8}$ " sheet of plywood will not be obvious to many of the students since few students will probably recognize that 0.6667 is $\frac{2}{3}$.

For question #9, try to have students think it through before just jumping to their calculators. The idea is to get students to really think about this... They need a block $\frac{2}{3}$ as thick as a $\frac{3}{8}$ inch sheet. If students are struggling, ask "***Is it a multiplication problem or a division problem?***"

8. You are now ready to create the permanent shim for that shed. The back corner will need an $8\frac{1}{2}$ inch thick shim. Using the same thickness of plywood as you have on your table, determine how many strips of plywood you will need for your shim. Show work or calculator keystrokes here and include units in your answer:

Answer: 22.6667 sheets

How many $\frac{3}{8}$ are there in $8\frac{1}{2}$? DIVISION

Two possible methods...

- One method $17\frac{1}{2} \times \frac{8}{3} = 68\frac{4}{3} \rightarrow 22\frac{2}{3}$
- $8\frac{1}{2} \div \frac{3}{8} = 22.66$ sheets (calculator)

Demonstrate the calculator steps on the Doc Cam and write out the key strokes on the board or in the notes with boxes.

8  1  2  3  8 = 22.66667

9. Were you able to use full thickness pieces of the plywood? If not, how thick does the piece of plywood need to be (that isn't full thickness) to make the shim exactly $8\frac{1}{2}$ inches thick? Be sure to *show your work or explain* how you determined your answer.

Answer: $\frac{1}{4}$ "

Calculation is: $0.6667 \times \frac{3}{8} = \frac{1}{4}$ "

Commented [CP1]: I am not sure it is a good idea to use $8\frac{1}{2}$ inches here. For the novice, the answer of $22\frac{2}{3}$ sheets is very confusing. $8\frac{3}{4}$ inches would be better as it allows students to calculate and find a whole number of plywood sheets. At this point in the lesson, the focus should remain on helping students recognizing this as a division problem and using the construction calculator to perform the calculation. $\frac{2}{3}$ of a thickness of a plywood sheet complicates the math too quickly. I would rather see students do a few problems with whole number answers first.

After students have some mastery of the concept, it would be a good time to give students problems that involve various thicknesses of plywood to come up with a plan to make a beam of a given thickness. For example, "If you have access to $\frac{3}{8}$ in plywood and $\frac{1}{4}$ in plywood, what combination of plywood could you use to make a laminated beam that is $8\frac{1}{2}$ inches thick?"

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Ask students to share their strategies to figure this out. Also show how it can be figured out without really using the calculator, just using a 'strip diagram' of the plywood. First, ask if anyone knows what 0.6667 is as a fraction without a calculator (hopefully a student will volunteer that it is $\frac{2}{3}$) then:

Draw a picture of the plywood as a rectangle split into 3 parts and ask... ***"what is the thickness of one part of this sheet if it is $\frac{3}{8}$ " thick?"*** If nobody answers, say... ***"if this plywood is THREE-eighths, how much would this one part be out of these THREE parts..."***

After students say " $\frac{1}{8}$ " write the number in one part, then color in two of the parts and ask if they can figure it out now...

Hopefully a student will say... *2/8 oh, that's $\frac{1}{4}$.*

Take away: we need 0.6667 (aka $\frac{2}{3}$) of a $\frac{3}{8}$ " thick sheet... the word OF here is multiplication

Commented [SP2]: look and see if $\frac{3}{8}$ " plywood is 3 plys. If it is, then demonstrate

Commented [SA3R2]: It typically is

10. Challenge: If you were going to make an $8\frac{1}{2}$ " thick shim, and you could any thickness of plywood, what thickness and how many pieces of plywood would you use? (You may combine different thicknesses of plywood for you shim, but you may only use standard thicknesses, which are $\frac{1}{4}$ ", $\frac{3}{8}$ ", $\frac{7}{16}$ ", $\frac{1}{2}$ ", $\frac{5}{8}$ " and $\frac{3}{4}$ ".

Possible Answers:

- 17 sheets of plywood that are each $\frac{1}{2}$ " thick.
- 10 sheets of plywood that are each $\frac{3}{4}$ " thick and 2 sheets that are each $\frac{1}{2}$ " thick

Problem Situation #2: Mastering Fractions on the Construction Master Calculator

Work with your group on the problems below to figure out how to calculate them in your calculator. Write down the buttons you pressed on your calculator to get your answers and make sure your entire group has the same answer for each question.

Duration	Activity (Indicate question number)	Suggested Structure (Indicate group, whole class or individual work)
15 minutes	Calculator Practice 11 - 17	Groups
10 minutes	Calculator Review 11 - 17	Whole Class

Notes: The point of this set of questions is to get the students to help each other to figure out how to use the construction master calculator.

Let the students work together on this. Tell students to **"take out your calculators and figure out the answer to #11. If you finish first, see if anyone in your groups wants your help."** Give them 2 minutes





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to work.
After 2 minutes ask a student to share their answer. Ask who got that. If not everyone did, get folks to share out all of their different answers.
Ask someone that got the right answer what they typed in to their calculator. Put the construction master calculator on the Doc Cam and follow along with their process. If it works correctly, write it into the middle column for #11.
Then tell the students to move on to questions 12 – 17. Remind them that the point of this practice is to help them figure out how to use an important tool in the trade... their calculator!
If students are struggling after a few minutes, fill in the answer column on the right and tell the students to focus on figuring out how to make the calculator give them those answers...
Allow students to get up and float between groups if an entire group is stuck. When it comes time to go over the answers... Pick out 6 students in advance and tell them they will be doing the calculations up on the doc cam with their calculator.

While the students do the doc cam demo, write down the key strokes on the board for each problem.

Be sure to talk about why the answer to the last problem is a decimal and not a fraction and discuss the issues with rounding when it converts to decimals.

Fill in the empty boxes for the calculator key strokes and the answer for each fraction problem in the table below:

Fraction Problem	Calculator Key Strokes	Answer from Calculator (with units if there are any)
Example (from #8 above) $8\frac{1}{2}'' \div \frac{3}{8}''$	8  1  2  3  8 =	22.66667
11. $4 \times 3\frac{1}{2}''$		
12. $\frac{7}{8} \times \frac{1}{2}''$		
13. $\frac{1}{2} \times 3\frac{7}{8}''$		
14. $3\frac{1}{2} \times 2\frac{7}{8}''$		

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15. $\frac{7}{8}'' \div \frac{1}{4}$		
16. $12\frac{3}{8}'' \div 4\frac{1}{2}$		
17. $10'' \div 2\frac{1}{8}''$		
18. $12' \div 4''$		

Answer to #11: output on calculator as fraction is 14"

4 $\boxed{\times}$ 3 $\boxed{\text{INCH}}$ 1 $\boxed{\div}$ 2 $\boxed{=}$

Answer to #12: output on calculator as fraction is 7/16"

7 divided by 8 x $\frac{1}{2}$ =

In general... Fraction times fraction--must convert one fraction to decimal to get a fractional answer
Can often get incorrect answer because calculator always rounds denominator to 2, 4, 8, 16. In those cases, the decimal will be correct but the fraction will be rounded

Answer to #13: output on calculator as fraction is 1 15/16"

1 $\boxed{\div}$ 2 $\boxed{\times}$ 3 $\boxed{\text{INCH}}$ 7 $\boxed{\div}$ 8 $\boxed{=}$

In general... Fraction times mixed number--must convert either the fraction or the mixed number to decimal to get a fractional answer.

Answer to #14: output on calculator as fraction is 10 1/16"

Step 1: convert 3 $\frac{1}{2}$ to decimal first (in the calculator)

2) 3.5 $\boxed{\times}$ 2 $\boxed{\text{INCH}}$ 7 $\boxed{\div}$ 8 $\boxed{=}$

Step

In general... Mixed number times mixed number---must convert one mixed number to decimal to get a fractional answer.

Answer to #15: output on calculator as fraction is 3 1/2 "

Step 1: convert second fraction to decimal first (in the calculator)

Step 7 $\boxed{\div}$ 8 $\boxed{\div}$.75 $\boxed{=}$ 8 fix this to be divided by 0.25

In general... Fraction divided by fraction--must convert second fraction to decimal

Note: again, this is not the correct answer. The calculator is rounding to the nearest 16th.

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Answer to #16: output on calculator as fraction is $2\frac{3}{4}$ "

Step 1: convert second mixed number to decimal first (in the calculator if necessary)

Step 2: $12\frac{Inch}{3} / 8\frac{Inch}{4.5} = 2\frac{3}{4}$ "

In general... Mixed number divided by mixed number--must convert second mixed number to decimal.

Note: This calculator always rounds denominator to 2, 4, 8, 16.

Answer to #17: output on calculator is 4.705882 (no units)

Note: Since both numbers are in inches, there is no need to convert.

$10\frac{Inch}{2} / 1\frac{Inch}{8} = 4.705882$

POINT OUT: Since there are no units, the answer is given as a decimal. To see the answer as a fraction, you have to tell it to make it in inches... (but don't forget, it will round the decimal!)

Hit INCH key 3 times to get the answer to convert to a fraction. **as fraction is $4\frac{11}{16}$ "**

In general... Whole number divided by mixed number—if the mixed number is not in inches, must convert mixed number to decimal first. can hit inch button a few times to turn decimal into closest fraction with 2, 4, 8, or 16 in denom.

MAKING CONNECTIONS

Record the important mathematical ideas from the discussion

Practice:

Spend time in class the next day reviewing #27 on page 32. Good extension problem.

Also talk about #21 on page 35... reference to scale (really, it's a proportion problem). See how students did.

Calculators OK--show your work and use units!

Pg 30-32 11, 12, 16, 19, 21, 23, 27

Pg 34-35 12, 20, 21, 25

Commented [SP4]: Should I add in Maury's Fraction Facts lecture notes here or somewhere in the lesson? or put them into the homework (pre or post) via a Kahn Academy link or youtube video for students to watch?

Commented [SHBP5]: These were the problems Maury assigned after this lesson

Commented [CP6]: A question for students: "Why does the calculator always round to the denominators of 2, 4, 8, and 16?"

Commented [CP7]: When students have to enter the second number as a decimals, do they have to write the number down and reenter it later? Might this be a good time to use parentheses? Not sure if the construction calculator has a parentheses or not.

For division problems, it make sense to have larger number first since it is impractical to division a smaller fraction by a larger fraction/ mixed number in real life applications.

Commented [CP8]: The homework problems are interesting, but they do not match the inclass activities. The homework focuses on addition and subtraction while the lesson is focused on multiplication and division.

Commented [SP9R8]: fixed

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