

Lesson 9: Determining Spacing

PREREQUISITE ASSUMPTIONS

Before beginning this lesson, students should

- Know how to use Construction Master
- Understand basic division

COMPETENCIES

Unit 1. Use of a Construction Calculator

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

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
- One thing I want to pay attention in my students' thinking ...
- One connection or idea I want to remember ...
- Have 4 sets of siding and 4 sets of posts and balusters.

Suggested Timeline

Duration	Activity (Indicate question number)	Suggested Structure (Indicate group, whole class or individual work)
3 minutes	Setting the stage and #1	Individual work
12 minutes	Questions 2 and 3	Groups
10 minutes	Question 4	Groups of 3 or 4
10 minutes	Discussion for Question 4 - equal spacing and math needed	Whole class
10 minutes	Question 5	Pairs
END DAY 1		
15 minutes	Baluster Spacing	Groups of 3 or 4
10 minutes	Discuss why a "ghost baluster" is needed, and space a "group" of one space and one baluster	Whole Class
15 minutes	Stair rise divide by 8 and round up vs divide by 7 and round down	Groups of 3 or 4

SPECIFIC OBJECTIVES

By the end of this lesson, you should understand that

- Spacing of things can be adjusted mathematically to create even spacing
- This is used in many different situations

By the end of this lesson, you should be able to

- Calculate and layout things with even spacing
- Use Construction Master to do this, using memory button

DEFINITIONS

Total rise: With respect to stairs, this is the vertical distance from the lower finished floor to the upper finished floor.

Riser: The vertical part of each step in a flight of stairs.

Siding: The exterior covering of a house. It is often made of horizontal pieces of wood (clapboards) that are partially overlapped.

Reveal: How much of a piece of siding is left visible. This is also called exposure.

Course: A horizontal row of a building material that has been applied to the house.

Baluster: The vertical pieces of wood or metal that are installed under a handrail to prevent falling. They are also called spindles.

PROBLEM SITUATION 1: Stairs

Insert a stair image

Wisconsin Code requires a riser NO GREATER THAN 8" for each riser in a stair in a private home.

1. The landing of a stairway is 59" inches high, and each rise is $7 \frac{3}{8}$ " high. How many risers does it take to reach the landing?
2. What if the total rise was instead 93"?
 - a. How many risers will you need?
 - b. Discuss with your group a strategy you can use to make sure each riser is the same height. Write down the strategy below.
 - c. What is the height of each riser??

PROBLEM SITUATION 2: Siding

In this problem situation you will be working to determine the spacing you need to install siding on a house. When doing a job like this, it is important to keep in mind:

- The siding must overlap a minimum of 1"
- A professional siding installation needs to have all of the courses of siding be exactly the same width.

You have siding that is $5\frac{3}{4}$ " wide. It is necessary to side a section of a house that is $40\frac{1}{2}$ " high. You need to determine what the 'reveal' (exposed amount) of the siding will be for each course to ensure that they are all EXACTLY the same width.

1. Discuss with your group a strategy you would use for this problem situation. Keep in mind that it is similar to the stairs problem. Write down the strategy below.

2. Now calculate:
 - a. The number of siding courses you need

 - b. The 'reveal' for each course

Siding is $5\frac{3}{4}$ " wide, must overlap a minimum of 1"
 Maximum exposure of $4\frac{3}{4}$ "
 $40\frac{1}{2}" / 4\frac{3}{4}" = 8.526316...$ so, round to 9. → 9 courses
 Then $40\frac{1}{2}"$ divide by 9 = $4\frac{1}{2}"$ reveal ($4\frac{1}{2}"$ exposure)

3. Now verify you are correct by using a dry erase marker to measure out $40\frac{1}{2}$ " on your desk to draw out your siding courses.
4. Additional Practice - now work on determining the spacing for two different siding scenarios
 - a. You measured the distance from the soffit to the bottom of the house to be $12' 8\frac{1}{2}"$. Your siding is $5\frac{3}{4}"$ wide.
 - i. How many courses will you need of the siding?
 - ii. What is the exposure amount for each course?

- i. $152.5" / 4.75" = 32.1 \rightarrow 33$ courses
- ii. $152.5/33 = 4.62"$ convert to fraction... $4\frac{5}{8}"$

- b. You measured the distance from the soffit to the bottom of the house to be $11' 1"$. Your siding is $7\frac{1}{2}"$ wide.
 - i. How many courses will you need of the siding?
 - ii. What is the exposure amount for each course?

- i. Remove 1" for overlap... 6.5" max exposure. $133" / 6.5" = 20.46 \rightarrow 21$ courses
- ii. $133/21 = 6.33"$ convert to fraction... $6\frac{3}{8}"$

(3) Measure the exposed amount on each course. What does it need to be to match for each course?

Do not tell them the math yet! But this is what it is:
 $40\frac{3}{4}"$ space to install siding into
 $40\frac{3}{4}' / 4\frac{3}{4}" = 8.57...$ so, round to 9. Then $40\frac{3}{4}"$ divide by 9= exposure ($4\frac{1}{2}"$ exposure)

(4) Work with your group to determine a way to figure this out without measuring (just using the numbers given and your calculator).

Allow the students to struggle for about 5 minutes on this. Some possible guiding questions...

5. What do you know?
6. How does the total height relate to the exposed amount?
7. What if you just had a space of 8", could you figure out the reveal then?
 - a. $8''/4 \frac{3}{4}''$ is less than 2, so then, what would you do?
 - b. Try to get the students to say that you'd round to 2 since you'd have 2 courses...
 - i. What would you do with the 2?
 1. Try to get the students to say...you'd round up to 2. Then divide $8''/2 = 4''$ exposure

Solution

40 $\frac{3}{4}''$ space to install siding into

When reviewing the solution, demonstrate the process on the Calculator

Make sure the math is written on the board and copied into the student's notes

Provide these summary notes for the students to write either in 'Making Connections' or in their notebook:

- a. In general, there is a set distance from the soffit to bottom of the house, and we want all courses to be exactly the same width.
- b. Don't forget when determining the exposure amount that the siding needs to overlap a minimum of 1"

PROBLEM SITUATION 2 : Balusters

Definitions needed to be provided (with pictures): Balusters, Rail, Posts

Given: posts are 4x4, rails are 2x4, balusters are 2x2

Code: ... there can not be more than four inches of space between balusters... how many balusters? Can be under, not over.

Problem Situation #1: Understanding Balusters activity

Part 1 – In the shop

Students are brought into the shop and given 2 4x4's and 3 balusters to complete the following two activities:

3. Space the 4x4's so that the distance between them is 15"
 - a. Now, place 2 balusters between them so they are evenly spaced
 - b. Draw a quick sketch with the measurements showing what you made

4. Space the 4x4's so that the distance between them is $20\frac{1}{2}$ "
 - a. Now, place 3 balusters between them so they are evenly spaced
 - b. Draw a quick sketch with the measurements showing what you made

5. PREDICT – what space would you need for 4 balusters that are evenly spaced?
 - a. WHY?

Stop for class discussion – did everyone predict #3 the same? What were people's reasons? Give everyone a 4th baluster and have them show their prediction.

Part 2 - Return to the classroom

6. Add in a question here for doing the 4th baluster distance purely with math. Give the total distance from #5 and ask them to figure out what math they use to get the spacing to match #5
7. How many balusters would you need for a rail that had 4x4 posts with a $42\frac{1}{2}$ " space between them?
8. How many balusters would you need for a rail that had 4x4 posts with a $46\frac{3}{4}$ " space between them?

their calculations for b and d.

The main focus of the discussion is the 'A/B' term and why it is necessary to round. Also important to note that B and C are equal when there is no rounding.

(1) You have two posts on a deck with a distance between them of 15"

a. What are the values of A and B from the formula?

A 2 x 2 actually has a cross section of 1.5", so

- $A = 15" + 1.5" \rightarrow 16.5"$
- $B = 4" \text{ (code minimum)} + 1.5" \rightarrow 5.5"$

b. Now calculate (A/B) from the formula _____

c. What does your answer from b. Represent?

b. $16.5/5.5 = 3$ exactly (no rounding necessary)

c. (A/B) is the number of groups of space+baluster

d. Now use the formula to calculate the variable C. Show your work below.

e. What does the C represent? Explain

d. $16.5/3 = 5.5$ This matches the value of B because there was no rounding. This may not be obvious to the students. It is not necessary to point this out until the discussion after #2

e. C is the spacing center to center

f. Draw a quick sketch showing your setup based on your answers- in your sketch, draw in the values for A, B and C. You can use the example shown above to help you.

(2) Now, you have two posts on a deck with a distance between them of 17"

a. What are the values of A and B from the formula?

A 2 x 2 actually has a cross section of 1.5", so

- $A = 17" + 1.5" \rightarrow 18.5"$

- $B = 4''$ (code minimum) + $1.5'' \rightarrow 5.5''$

- b. Now calculate (A/B) from the formula _____
 c. What does your answer from b. Represent?

- b. $18.5/5.5 = 3.36$ so it is necessary to round it to 4
 c. (A/B) is the number of groups of space+baluster. It must be a whole number.

- d. Now use the formula to calculate the variable C. Show your work below.
 e. What does the C represent? Explain

- d. $18.5/4 = 4 \frac{5}{8}''$ This doesn't match the value of B because there was rounding.
 e. C is the spacing center to center

- f. Draw a quick sketch showing your setup based on your answers- in your sketch, draw in the values for A, B and C. You can use the example shown above to help you.

Discussion will take about 10 minutes:

The discussion here should be how A/B represents the NUMBER of Balusters + spaces. So, it can't be anything except a whole number.

Ask why we round UP and not DOWN. Would there be spacing situations where you need to round DOWN?

If students are still confused even after reviewing the sketches and calculations up on the board, do an example: How many balusters would you need for a rail that had 4x4 posts with a $46 \frac{3}{4}''$ space between them?

$A = 46.75'' + 1.5'' = 48.25''$ and $B = 5.5''$ so $A/B = 8.77 \rightarrow 9$ balusters + spaces

$48.25/9 = 5 \frac{3}{8}''$ center-on-center

And draw a quick sketch

NOTE: Students need to write the formula down in their notes somewhere and make sure each variable is defined.

If short on class time, assign problem situation 3 as homework.

Problem Situation #3: You are building a new deck for a client. You have two posts on your deck. The distance between the posts is $78\frac{3}{4}$ ". It's your job to build the rail:

1. Before taking out a calculator... estimate how many balusters do you think you'll need? Explain your estimation strategy

Round 78.75 to 80 and use 6 for B... $80/6$ is about 13. So, I estimate 13 balusters.

2. Now, calculate the actual number of balusters you need

$78.75 + 1.5 = 80.25$
 $A/B = 80.25/5.5 = 14.6$ round up to 15
 Answer: 15 balusters are needed.

3. What is the spacing between each baluster?

$80.25/15 = 5\frac{3}{8}"$

CHALLENGE (for those done early): What if your balusters were $7/8"$ stock instead of 2x2's?

1. How many balusters?
2. What is the spacing?

MAKING CONNECTIONS

State the main idea of the lesson

Using division and rounding to find equal spacing for many things

PRACTICE

Note: When building stairs, the Wisconsin building code requires that all risers be $\leq 8''$ and that all risers be the same.

1. For a flight of stairs with a total rise of 96''
 - a. What is the height of each riser? Show your work.
 - b. How many risers will the stairs have? Show your work.
2. For a flight of stairs with a total rise of 101''
 - a. What is the height of each riser? Show your work.
 - b. How many risers will the stairs have? Show your work.

Note: When installing wood siding on a house, it is important that each piece overlap the piece below it by at least 1'' but no more than 2'' as shown in the drawing below. Best practice is to install the siding so that each course of siding has the same reveal.

3. The height from the bottom to the top of a wall is 120''. You will be installing wood siding that is 8'' wide. If each piece of siding must overlap the previous piece by no less 1'' and no more than 2''
 - a. What is the reveal of each course of siding? Show your work.
 - b. How many courses of siding will there be on the finished wall? Show your work.

4. The height from the bottom to the top of a wall is 120". You will be installing wood siding that is $6\frac{3}{4}$ " wide. If each piece of siding must overlap the previous piece by no less 1" and no more than $1\frac{3}{4}$ "
 - a. What is the reveal of each course of siding? Show your work.
 - b. How many courses of siding will there be on the finished wall? Show your work.

Note: When building hand rail, Wisconsin building code requires that the spaces between balusters be ≤ 4 ". Furthermore, it is best practice to make all of the spaces between balusters equal.

5. The distance between posts for a hand rail is 78". What is the on center spacing of $1\frac{1}{2}$ " wide balusters? Show your work.
6. The distance between posts for a hand rail is 6'-4". What is the on center spacing of 1" wide balusters? Show your work.