

Lyle Courthage - Director of RPOS
Landon Skully - Construction Instructor - CHR High School
Amanda Kobak - Math Instructor - OMA High School
Clay Baucus - Math Instructor - Helena High School
Brian Dyechild - Math Instructor - Capital High School
Paul Stetson - RPOS Facilitator - Helena Public Schools



<http://mus.edu/2yr/RPOS/Math-In-CTE.asp>

Squaring a foundation

Staircase Stringers





Montana

Math-In-CTE



How to Integrate Math Skills into your CTE Course using the NRCCTE Math-In CTE Model



Lyle Courtnage - Director of RPOS

Landon Stubbs - Construction Instructor - CMR High School
Amanda Kohut - Math Instructor - CMR High School

Clay Burkett - Math Instructor - Helena High School
Brian Oswald - Math Instructor - Capital High School

Paul Stetzner - RPOS Facilitator - Helena Public Schools

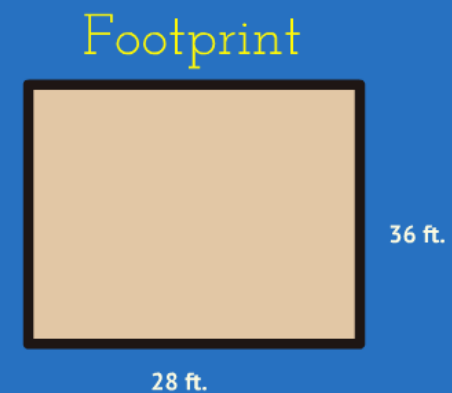
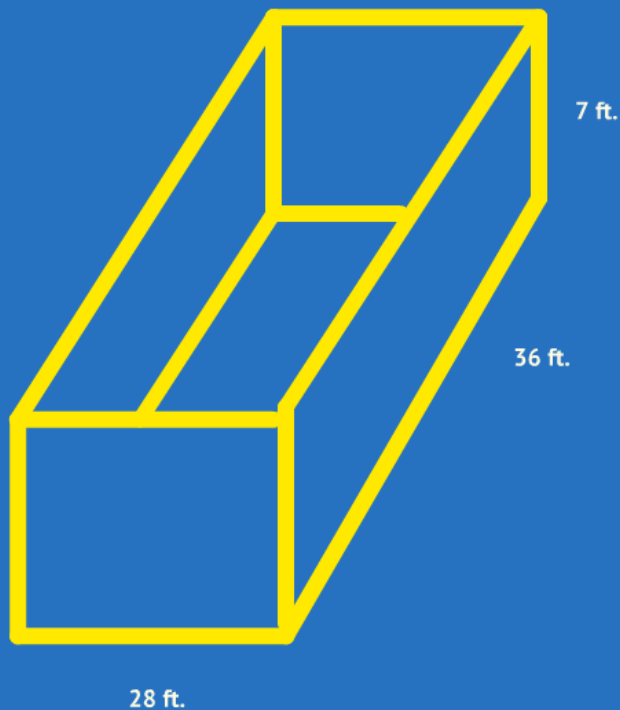
Let's Excavate!



Excavators come in many different sizes.



EX: Let's find out how much earth we need to remove if we want to build a house that measures 36 ft wide, 28 ft long, and needs to be 7 ft deep.



Soil Data Tables

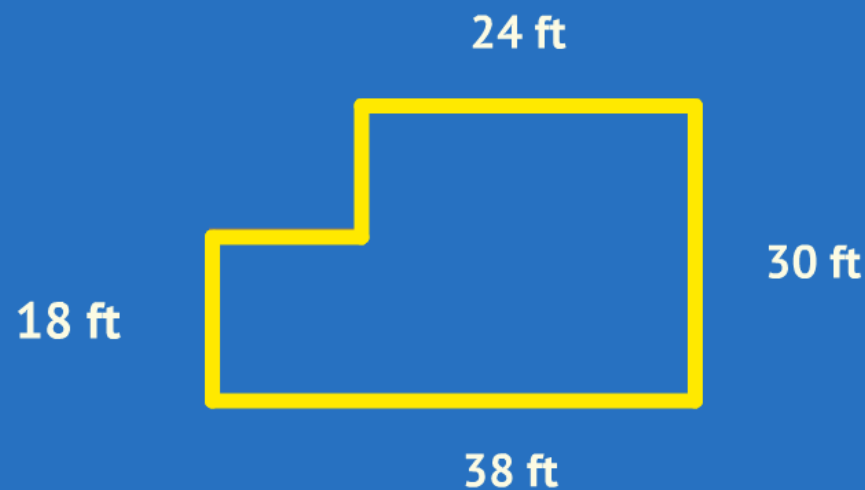
Swellage Factors

Soil Type	100% relative compaction	Excavated and loose
Sand	1	1.15
Sandy – Loam	1	1.20
Clay – Loam	1	1.30
Clay	1	1.35

1. Find the volume in yd^3 that a backhoe bucket can hold if it is 24 in. wide, 36 in. deep, and 30 in. tall.



2. Find the amount of earth in yd^3 that will be removed if you are laying a slab for a garage with extra parking pad. The dimensions are shown below, and the depth needs to be 18 in.



3. Find the amount of earth in yd^3 that will be removed if you are installing a square swimming pool that's sides are 21 ft. and has a depth of 5 ft. Assume the slope of the property is zero. Also give the number of truck loads needed to haul the soil away assuming 25% expansion.

4. Find the volume of a rectangular prism that is 16 ft. by 18 ft. by 6 ft.

**5. The area of a L shaped playground is 370 ft^2 .
Find the volume in yd^3 of pavement if it is 6 in.
deep.**

If you were a hotel clerk and a customer called and asked you for the size of the hotel room, describe how and what you would tell the customer.

You are buying a cargo type van for your construction company. Dealer A has a van with a box that is 10 ft long, 6 ft wide, and 5 ft high, while Dealer B's van measures 9 ft long, 7 ft wide, and 6 ft high. What is the cargo space for Van A and Van B. Which can will you buy and why?

Math-in-CTE Lesson Plan Template

Lesson Title/Lets Extension:		Lesson #
Author(s):	Phone Number(s):	Email Address(es):
Bruce Banta	MSG-268-6270	Bruce_Banta@njrcs12.net
Amanda Kishi	MSG-268-6105	amanda_kishi@njrcs12.net
Occupational Area:	Construction	
CTE Concept(s):	Extension	
Math Concepts:	area, volume, units	
	Common Core State Standards – MT: N-G, A-REI-C, G-GMG	
Lesson Objective:	Students will be able to calculate the amount of material that will need to be removed based on a given job plan. Students will be able to compare and contrast of volume. Students will know units of volume for excavating. Students will be able to apply formulas to solve a variety of volume and excavation problems.	
Supplies Needed:	Printed calculator Optional: not needed either	
THE "7" ELEMENTS	TEACHER NOTES (and answer key)	
1. Introduce the CTE lesson. They were going to dig and how excavated the amount of dirt to remove from the job site.		
ASQ: What unit of measurement will we use to calculate the amount of work being done?	• Volume, cubic, measured in feet and formatted to cubic yards.	
ASQ: Why is it important to know how much earth needs to be removed?	• Calculate cost and determine how and amount of equipment to field at the site.	



ASQ: What measurement information will we need to plan an excavation?	• Volume (area, volume, unit of length, feet assembly, job site layout, etc., with given variables (radius, etc.)
ASQ: Who is responsible for calculating earth removal on a job site?	• Foreman / Superintendent / SSO / Supervisor / Project Engineer / Laborer / Estimator/Calculator
2. Assess students' math awareness as it relates to the CTE lesson. Bring up pictures, power point of various sizes of excavating equipment.	
ASQ: Which of these is responsible for use on our jobsite? Where might you use the other?	• How they are used and why they require to emphasize the importance of measurable equipment.
ASQ: What do we call a 3-dimensional measurement?	• Volume
ASQ: What do we call a 2-dimensional measurement?	• Area / in construction we call the job layout
ASQ: Why are some corners of other blocks that are measured in volume?	• Square size, measured in 2-dimensional, meaning feet, diameter, etc. (radius, etc.) (circle, something else)
ASQ: How would we calculate the volume of earth we need to remove (cubic yard)?	• $V = Bh$ (area of the base x height) $V = \text{length} \times \text{width} \times \text{height}$ The will be measured in feet, and will need to be converted to yards $V / 27 = \frac{27}{27} \times \frac{1}{27} = \frac{1}{27}$



3. Work through the math examples embedded in the CTE lesson.	
ASQ: Do a basic form of a job site how much earth we need to remove if we want to build a house that measures 30' x width, 20' x long, and needs to be 7' deep.	• Show plans in power point. • Talk about finding benchmarks, calculate, start using benchmarks as baseline. For the example we will assume price of priority to area. Talk about over dig, work area, etc.
ASQ: What type of unit will be used to give the final amount of earth that needs to be removed?	• Cubic yards (cubic)
ASQ: What type of unit are given on our plans?	• Feet (cubic)
ASQ: How do we start to measure volume of earth that needs to be removed?	• Use the formula for the volume of a rectangular prism: $V = Bh = \text{length} \times \text{width} \times \text{height}$ $V = 20 \times 30 \times 7 = 3500 \text{ ft}^3$
ASQ: Is this in the units we want? How do we convert?	• $\text{cubic ft} \times \frac{1}{27} = \frac{3500}{27} \times \frac{1}{27} = 109 \text{ yd}^3 \times \frac{1}{27} = 4 \text{ yd}^3 \text{ (L. 100)}$
ASQ: What excavation equipment would be appropriate for this job?	• Powerback would be a backhoe with a 1 yd ³ bucket. Backhoe has long if backhoe on bucket and the wheel would fit in a corner(s).
ASQ: What happens if the soil is not an excavator?	• When soil is difficult, giving excavator, the volume is increased. See Cost Tables in power point and on hand out. Excavation rates are usually 75-100%. We will use 25% for our very heavy soil. $261.2 \text{ yd}^3 \times 1.25 = 326.5 \text{ yd}^3$
ASQ: How many truck loads will it take to remove all the earth?	• A truck can haul approximately 10 yd ³ based on size and weight. We will need 33 trucks.



4. Work through additional, contextual math-in-CTE examples.	
1. Find the volume in yd ³ that a concrete surface can hold if it is 10 ft wide, 30 ft deep, and 3.5 ft tall.	• With the given dimensions of feet by dividing each by 12. $V = Bh = \text{length} \times \text{width} \times \text{height}$ $V = 10 \times 30 \times 3.5 = 1050 \text{ ft}^3$ Convert: $1050 \text{ ft}^3 \times \frac{1}{27} = 38.89 \text{ yd}^3$ The amount probably will be a job, but it's not a job, you try and try actually excavate problems.
2. Find the amount of earth in yd ³ that will be removed if you are trying to build a garage with a concrete parking pad. The dimensions are 10 ft wide, 10 ft deep, and the depth needs to be 10 ft (depth to parking pad).	• The height will need to be converted to 2 columns: $10 \times 10 \text{ and } 4.30 \text{ or } 35 \times 10 \text{ and } 28 \times 7$ The area of the base will be 475 ft ² times the depth $(\frac{1}{12} \times 10)$ $V = 475 \times 10 = 4750 \text{ ft}^3$ Convert: $4750 \text{ ft}^3 \times \frac{1}{27} = 175.93 \text{ yd}^3$
5. Work through additional math examples.	
3. Find the amount of earth in yd ³ that will be removed if you are installing a square swimming pool that is 100 ft by 21 ft, and has a depth of 5 ft. Assume the shape of the cavity is now. Also give the volume of back-haul needed to raise the soil away, assuming 25% expansion.	• $V = Bh = \text{length} \times \text{width} \times \text{height}$ Convert: $100 \times 21 \times 5 = 10500 \text{ ft}^3$ Expansion of 5 yd ³ = $20 \times 20 \times 10 = 4000 \text{ yd}^3$ Total: $10500 \text{ ft}^3 = 388.89 \text{ yd}^3$
4. Find the volume of a rectangular prism that is 10 ft by 15 ft by 6 ft.	• $V = Bh = \text{length} \times \text{width} \times \text{height}$ Convert: $10 \times 15 \times 6 = 900 \text{ ft}^3$
5. The area of a L-shaped playground is 270 ft ² . Find the volume in yd ³ of basement if it is 6 ft deep.	• Rectangle $A = \text{width} \times \text{length} = 105$ $A = Bh = 270 \times 3 = 810 \text{ yd}^2 \times 3 = 2430 \text{ ft}^3$ Convert: $2430 \text{ ft}^3 \times \frac{1}{27} = 90 \text{ yd}^3$



6. Students demonstrate their understanding.	
ASQ: If you were a contractor and a customer called and asked you for the area of the floor, can, describe how and what you would use the calculator.	• Convert what you know, and encourage them to use the calculator.
ASQ: You will be doing a large job site for your construction company. Order a job of dirt with the dimensions 10 ft x 10 ft x 10 ft, and 10 ft x 10 ft x 10 ft, and 10 ft x 10 ft x 10 ft. Which one will you buy and why?	• $V = Bh = 10 \times 10 \times 10 = 1000 \text{ ft}^3$ • $V = Bh = 10 \times 10 \times 10 = 1000 \text{ ft}^3$ • Talk about factors that affect what they buy (just what they are doing)
7. Formal assessment.	Key attached
Task: 3 questions, attached document.	
NOTE:	



Squaring a foundation

Math-in-CTE: Pythagorean Theorem Lesson

1. Introduce the CTE lesson.

Today we are going to practice laying out foundations and checking to make sure they are square.

Math-in-CTE: Pythagorean Theorem Lesson

2. Assess students' math awareness as it relates to the CTE lesson.

- Students will use a ruler, some string, and a blank sheet of paper to draw a 6" x 8" rectangle on the piece of paper.
- Can anyone explain how to make sure we are parallel from the edge of the paper?
- How will we guarantee that the sides are square?
- How will we locate the other corners?

Math-in-CTE: Pythagorean Theorem Lesson

3. Work through the math example embedded in the CTE lesson.

- Using a pencil, rule and some string, draw a 6" x 8" rectangle on your paper.
- Students use Pythagorean Theorem in the form of a 3-4-5 right triangle to square up the corners.

Math-in-CTE: Pythagorean Theorem Lesson

4. Work through related, contextual math-in-CTE examples.
 - Students will use the Pythagorean Theorem to determine the length of the common rafter on a gable roof given the total rise and run.

Math-in-CTE: Pythagorean Theorem Lesson

5. Work through traditional math examples.
 - Students will solve three traditional math examples using the Pythagorean Theorem as might be found in a math textbook.

Math-in-CTE: Pythagorean Theorem Lesson

6. Students demonstrate their understanding.
 - To more closely simulate the process of laying out a square foundation, we are going to “stake out” a 12” x 15” rectangular foundation on a piece of lumber using some string and nails. What length will we need for our diagonal to get our right angle corners? Working with a partner, use a tape measure, string and four nails to stake out the rectangle.

Math-in-CTE: Pythagorean Theorem Lesson

7. Formal assessment.

- Students will work in groups (three or four) to go outside and stake out a 24' x 24' foundation using some string, four stakes, and a hammer. They will also need a calculator to find the correct diagonal length to the nearest 16th of an inch. You may want the students to determine the diagonal length prior to going outside.

Math-in-CTE: Pythagorean Theorem Lesson

Some difficulties we encountered:

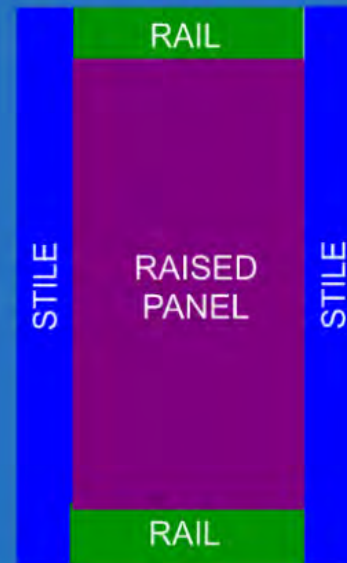
- Students had challenges working between feet and inches
- Students had trouble working between fractions and decimals
- Students really struggled when we combined the two issues above and the Pythagorean Theorem

Math-in-CTE: Pythagorean Theorem Lesson

As a result of the difficulties encountered we:

- Worked with students on converting between feet–inches–fractions of an inch.
- Broke down the Pythagorean Theorem into sub-sets of skills and worked on each skill.
- Took an approach of doing a few minutes of math each day instead of “spending a day on the math”.

INTRODUCTION RAISED PANEL DOORS



Working with Mixed Numbers

Mathematical Language

Convert to improper fractions.

Find the common denominator.

Simplify the fraction.

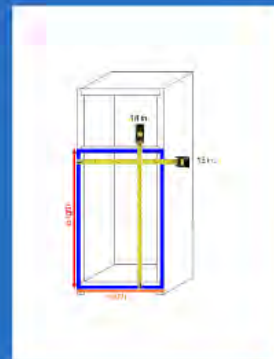
Add or subtract the numerators.

Construction of a Door Panel

Materials: Boards at least 5.25" wide.

1. Measure dimensions for the door.
2. Determine the number of doors.
3. Plane all boards to 0.78"
4. Sand all boards to 0.75" on the speed sander.
5. Joint 1 edge on all boards.
6. Rough cut boards to 0.5" longer than finished sizes.
7. Square all boards on a table saw to a minimum of 5.5" wide.
8. Cut rails to finished length on the table saw.
9. Set shaper and check using scrap wood.
10. Machine end-grain on the rails.
11. Change shaper bits to cut rails and stiles length-wise.
12. Rip all boards to 2.5" wide on the table saw.
13. Cut stiles to finished length.
14. Cut raised panel to size.
15. Glue pieces together.

Finding the Overall Door Dimensions

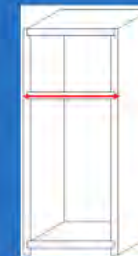


rail length = total width - 2 x stile + 2 x profile circ

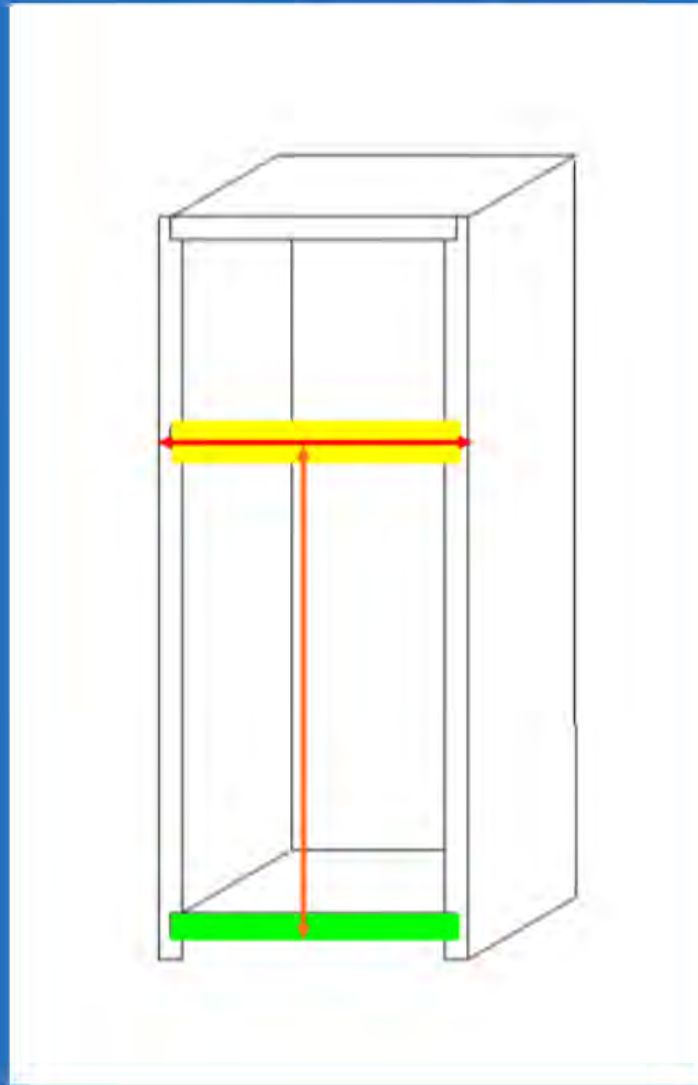
rail length = total width - 2 x 2.5" + 2 x 3/8"

rail length = total width - 5" + 3/4"

rail length = total width - 4 1/4"



stile length = distance between bottom shelf and mid-line of face frame

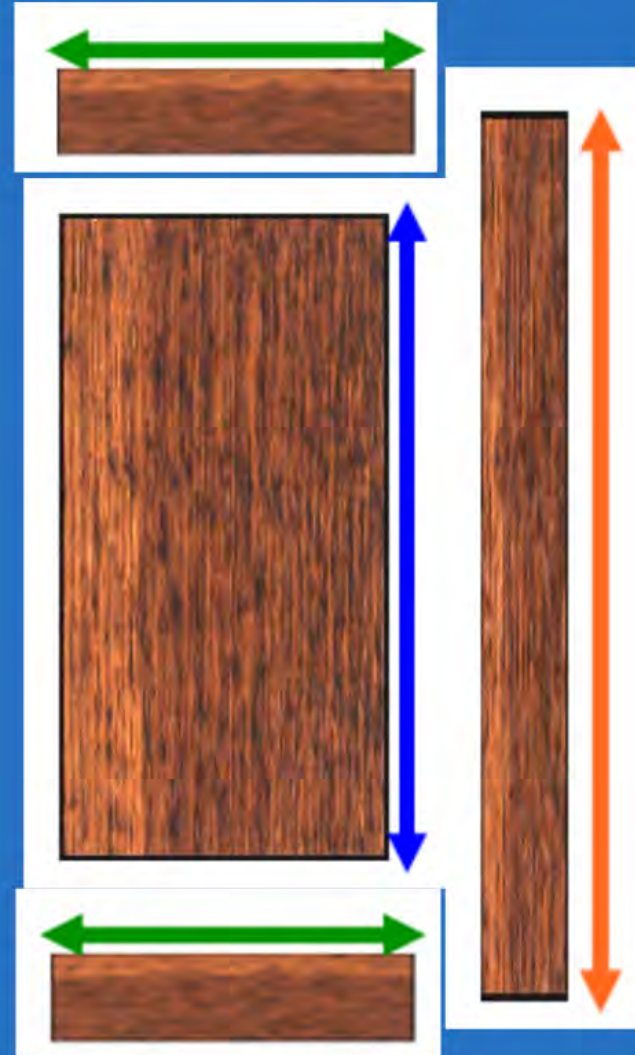


Panel Length = Stile Length - 2 x Rail Width + 2 x Profile Cut Gap

Panel Length = Stile Length - 2 x 2.5" + 2 x 1/4"

Panel Length = Stile Length - 5" + 1/2"

Panel Length = Stile Length - 4.5"

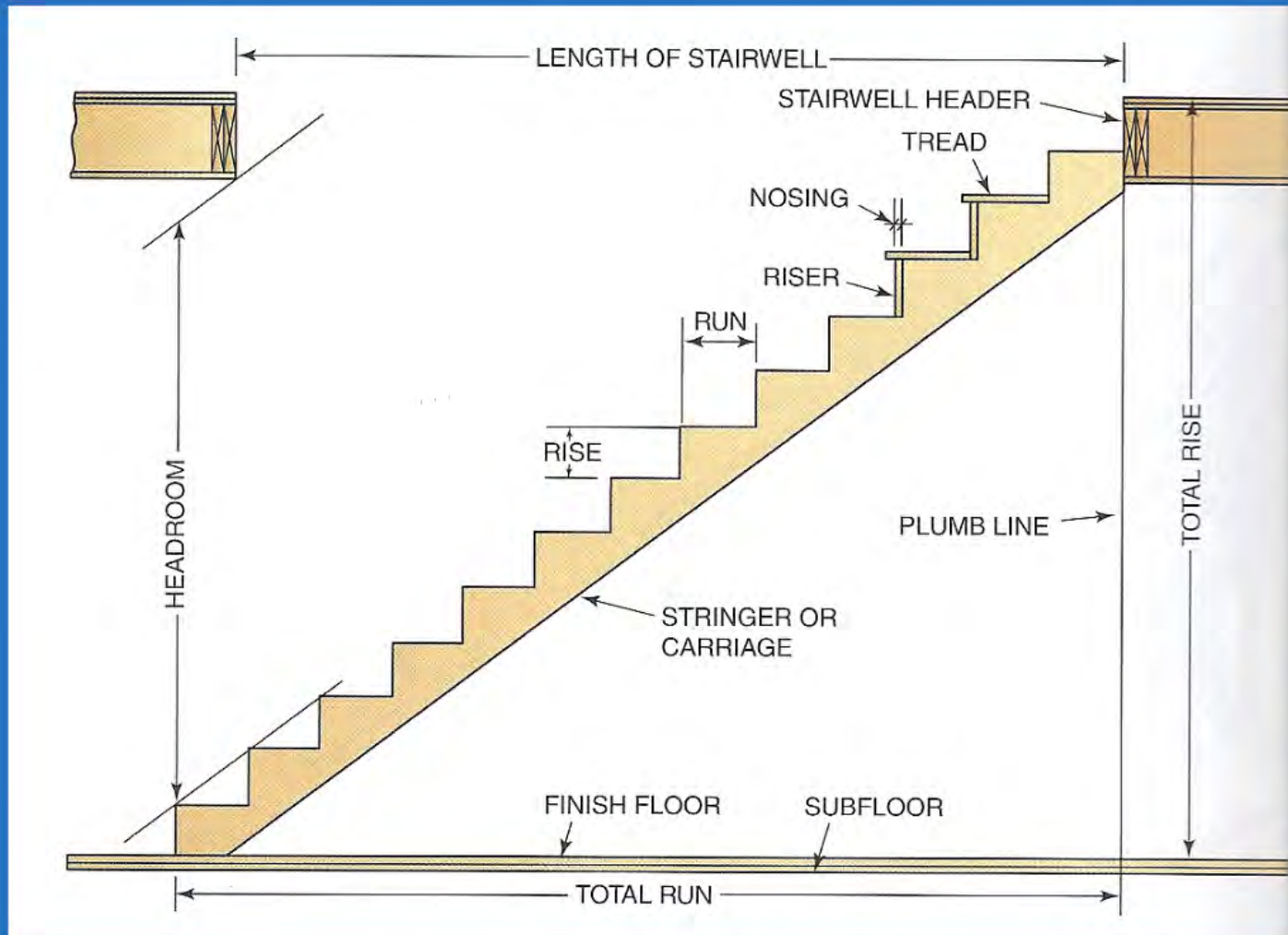


Panel Width = Rail Length - 1/4"

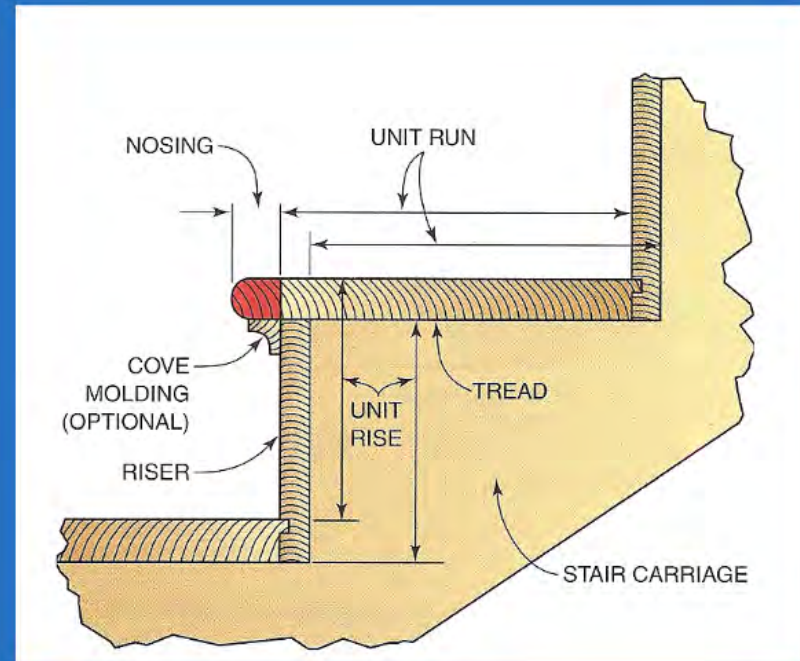
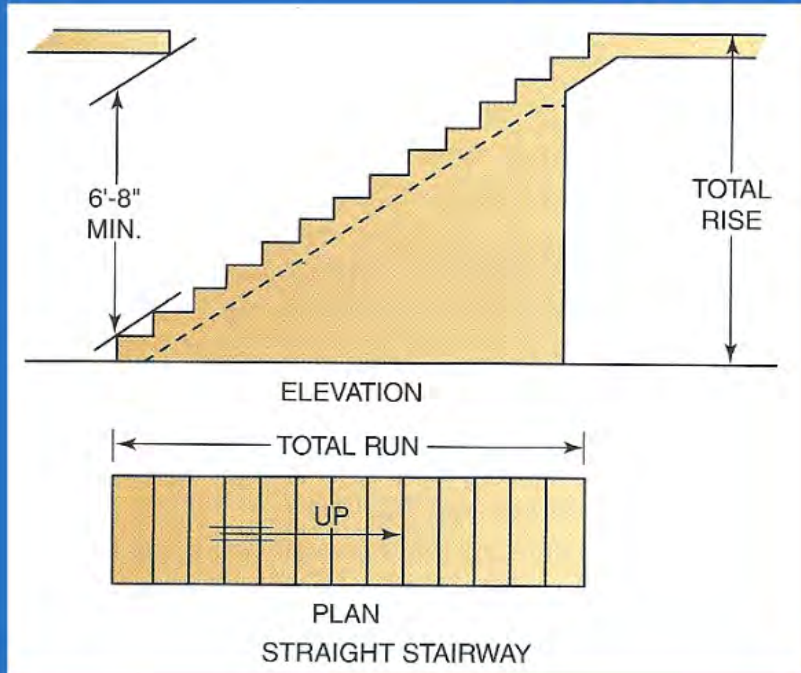


Staircase Stringers

Staircase Stringers Project

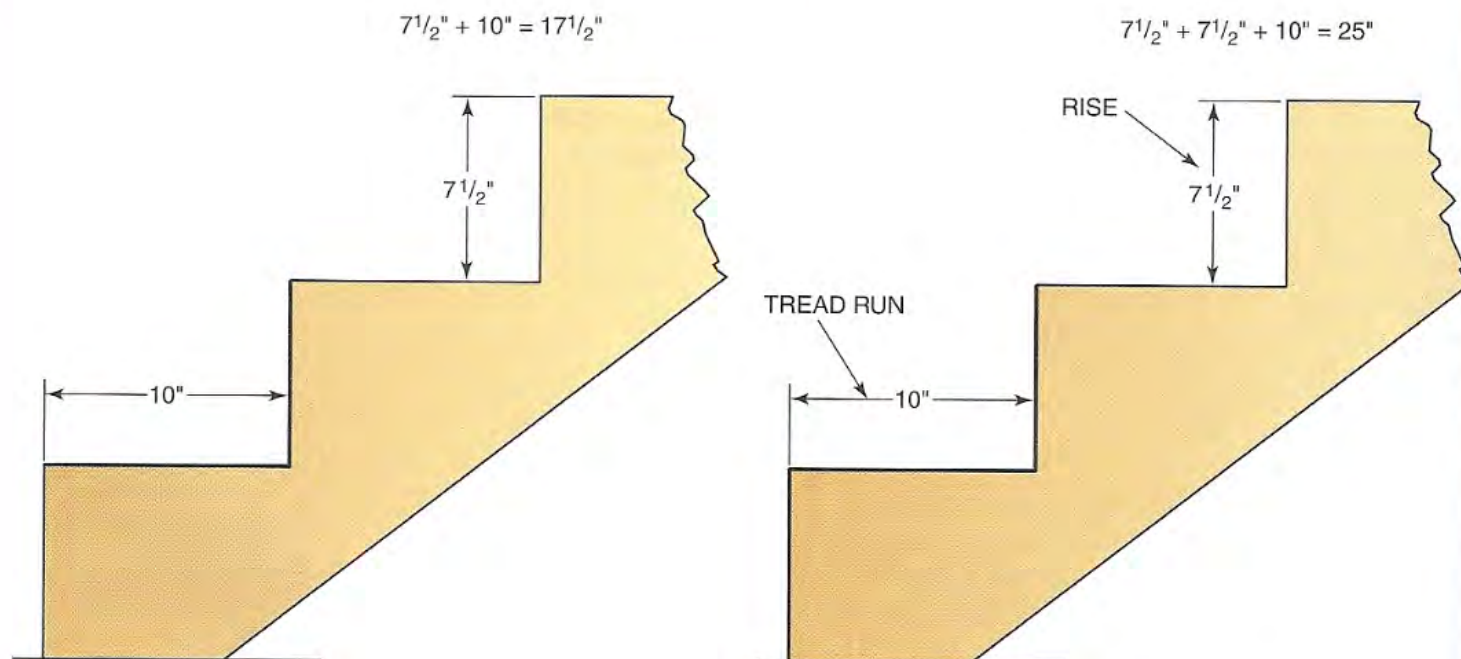


Staircase Stringers Project



Staircase Stringers Project

Two formulas are used to determine the unit run for stairs (Fig. 16-7).

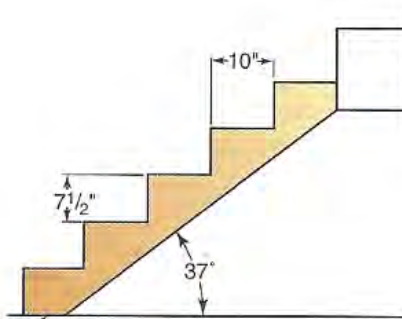
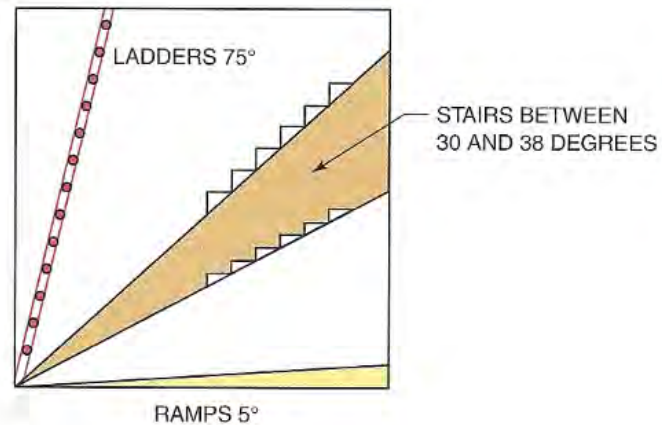


17-18 METHOD – ONE RISE PLUS ONE TREAD RUN SHOULD EQUAL BETWEEN 17 AND 18 INCHES.

24-25 METHOD – THE SUM OF TWO RISES AND ONE TREAD RUN SHOULD EQUAL BETWEEN 24 AND 25 INCHES.

NOTE: INTERNATIONAL BUILDING CODE SPECIFIES A MAXIMUM RISE OF $7\frac{3}{4}$ INCHES AND A MINIMUM TREAD RUN OF 10 INCHES.

Staircase Stringers Project



STAIRS WITH THE RISE AND TREAD RUN SHOWN ABOVE TRAVEL WITHIN THE PREFERRED ANGLE RANGE FOR SAFER AND MORE COMFORTABLE USE.

Staircase Stringers Project

- Team taught with carpentry teacher to cover both the math and building codes properly.
- Practiced calculations, then practiced laying out a stringer using butcher paper.
- Final assessment involved calculating, laying out, and cutting a staircase stringer out of OSB.
- Next year will incorporate Technical Writing to produce instructions for laying out a stringer

Staircase Stringers Project

Stringer / staircase

$2' \times 6''$
 $1' \frac{1}{2}'' \times 5 \frac{1}{4}''$
 $2' \times 10''$
 $1' \frac{1}{2}'' \times 9 \frac{1}{4}''$
 $3'$
 $1''$
 Runner
 $6' \frac{1}{2} = 7 \frac{1}{2}$ per 1

$9' \frac{1}{2} + 1' \frac{1}{2} = 10' \frac{3}{4} = 3''$
 $10' \frac{3}{4} + 36'' = 46' \frac{3}{4}''$

$a^2 + b^2 = c^2$
 $\frac{46.75}{7} = \frac{6.68}{6}$

lay out stair stringer
 Total Rise - $46' \frac{3}{4}$
 # of Risers - 7
 Riser Height - $6' \frac{11}{16}$
 Tread length - 10
 Total Run - 60"
 Hipper Stringer length -
 # of steps = 6

$\frac{46.75}{6} = 7.79$ $\frac{79}{10} = \frac{x}{16}$
 $\frac{6x}{100} = \frac{x}{16}$ $\frac{1264}{100} = 12.64$
 $\frac{1088}{100} = 10.88$
 $6' \frac{11}{16}$

$a^2 + b^2 = c^2$
 $6' \frac{11}{16}^2 + 60^2 = c^2$

$6' \frac{11}{16} \times 3600 = 3606.04$
 $60.65 \div 12 = 5.054$

Staircase Stringers Project



Staircase Stringers Project



Staircase Stringers Project



Literacy - In - CTE



<http://mus.edu/2yr/RPOS/Math-In-CTE.asp>