

Lesson #1: Building Stairs Project (12 Days)

Objectives

Students will be able to...

- Determine the distance between two points on a coordinate plane using the Pythagorean theorem.
- Analyze given information, formulating a plan or strategy, determining a solution, justifying the solution, and evaluating the problem-solving process and the reasonableness of the solution.
- Apply mathematics to problems arising in everyday life, society, and the workplace.
- Work cooperatively with others.

Common Core Standards

LS 11-12.6
RSIT 11-12.2
RLST 11-12.2
Writing 9-10.5
Problem Solving/Critical Thinking 5.4
Health and Safety 6.2, 6.3, 6.6, 6.12
Responsibility and Leadership 7.4, 9.3
CCSS.MATH.PRACTICE.MP6
CCSS.MATH.PRACTICE.MP2
CCSS.MATH.PRACTICE.MP1
Residential and Commercial Construction Pathway D2.1, D2.2, D3.1, D3.7

Materials

Step Building Worksheet
Building Stairs Instructions
Bill of Materials
Self-Evaluation

Lesson Sequence

- Pass out the *Step Building Worksheet*. Have students work with a partner to create a sketch of a set of stairs on butcher paper. They will share their data with the class once the finish. Support students as needed. (2 days)
- Pass out the *Building Stairs Instructions*. Review directions as a class. Students will design a set of dog steps in compliance with California Residential Building Code. They will make a sketch of their proposal with the correct specifications of each part of the stairs. Have students fill out their *Bill of Materials*. Then they will complete their bill of materials. Support students as needed throughout the project. (10 days)
- Once students have finished their projects have students place their final products out and walk around the room looking at their classmate's pet stair projects.
- Have students complete their self-evaluation form and use rubric to grade student's final projects.

Assessment

Informal observations throughout project.
Use rubric to grade student's final projects.

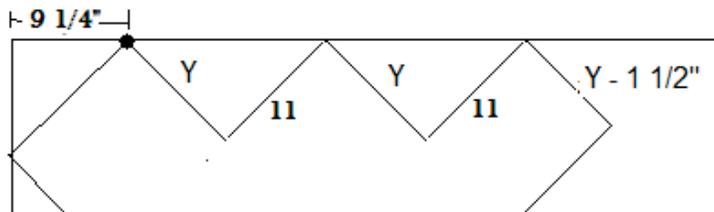
Accommodations/Modifications

One on One Support
Strategic Partners
Check for Understanding
Calculators
Extra Time If Needed

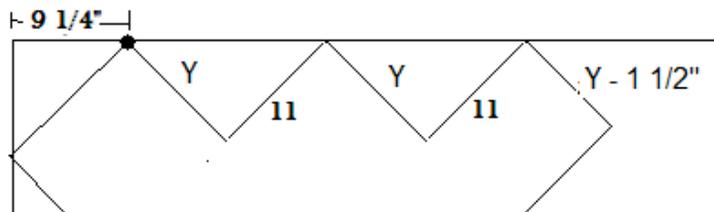
Step Building Worksheet

You will be working with a partner to create a sketch of a set of stairs on butcher paper. You will be sharing your data with the other partner groups in the classroom.

1. Mark a stringer on a piece of butcher paper (1' wide X 4' long) using a carpenter's square. Normally, the stringer is cut out of a 2"x12" board. Today, you will initially use butcher paper for the stringer. The marked stringer should look like this: (note what Y = at the top of the page) There should be 2 steps plus the top landing. If you mess up, you will need to make do. Check this measurement with the teacher before cutting the stringer. Drawing is not to scale.



2. Cut the stringer with scissors. Normally you would use the first stringer as the pattern for the second one. But for this activity, the other pair of students will try to match your stringer without tracing the first stringer. Measure twice, cut once.
3. Determine the length of the 2 x 12 (butcher paper) needed if your paper had not been precut. Hint: How many hypotenuses do you need?



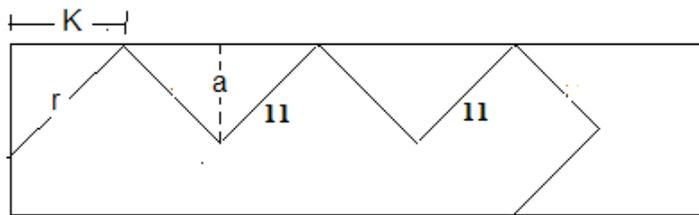
4. Calculate the slope of your steps. Calculate the slope of the steps of 4 other groups. Record the slopes here:

Group # _____ Slope _____

BUILDING INDUSTRY TECHNOLOGY ACADEMY: YEAR TWO CURRICULUM

5. Looking at your steps, why do you need the bottom rise (Y) to be 1 1/2" shorter than the other rises?

6. Using the drawing below, what is the geometric term for "a" "r" needs to be 11 inches. Why? Using your steps, measure the distance "a" and record here _____ Find the value of "K" mathematically (it may not be 9 1/4" as originally given).



7. How many steps would you need for the top of the steps to reach a height of 48" assuming each rise must be equal and be the same as your Y value plus or minus 1/2 "?

8. What is the length of the 2 x 12 needed for 1 stringer if you needed the top of the steps to be at a height of 48". Use the rise you used in #7.

Stair Layout Worksheet

Given the total rise below, determine the riser height, number of risers, number of treads, and length of 2x12 stringer needed for 2 stringers (rounded up to the nearest foot). Please show calculations in box to justify your answer.

Total Rise	Riser Height	# of Risers	# of Treads	Stringer Length
48"				
70 1/2"				
9'				
97 1/4"				
23 3/4"				

How to Cut Stair Stringers

Step 1:

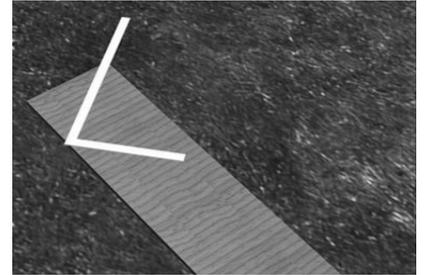
Measure twice for your total rise and run and your individual rise and run. Ensure your math and calculations are correct.

Your total rise is the vertical height from one story to the next. Your individual rise is the vertical height of each step.

Your total run is the horizontal distance between one story and the next. The individual run is the horizontal distance of each step

Step 2:

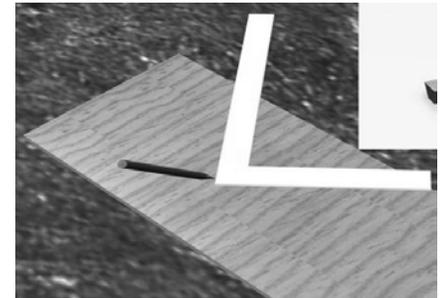
Place a framing square near the end of a 2 x 12 (38 x 286 mm) board. The board should be at least 12 inches (30.48cm) longer than the planned stairs.



Step 3:

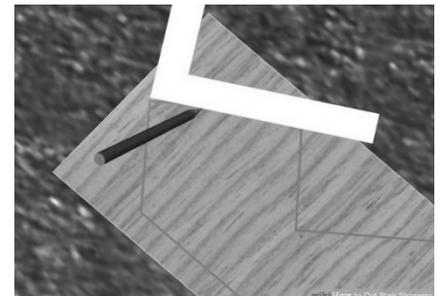
Use the rise and run figures marked on the outside scales of the square that matches your measurements. These figures should touch the upper edge of your board.

The short end of the square (tongue) should be on the rise measurement. The long end of the square (body) should be on the run measurement.



Step 4:

Mark the outline of the square's outer edges. Move the square down to extend the run line to the lower board edge.



Step 5:

Make another mark to the right of the run line that is parallel and equal to the thickness of the thread. This marks the stringer bottom.

Step 6:

Slide the framing square along the board to the right so your scale run figure touches the end of your first marked run line.

Line up the scale's rise figure at the top edge. Mark the new outline and repeat until you have marked 1 extra pair of runs and rises.

Step 7:

Cut notches into the stringer and remove each right angle.

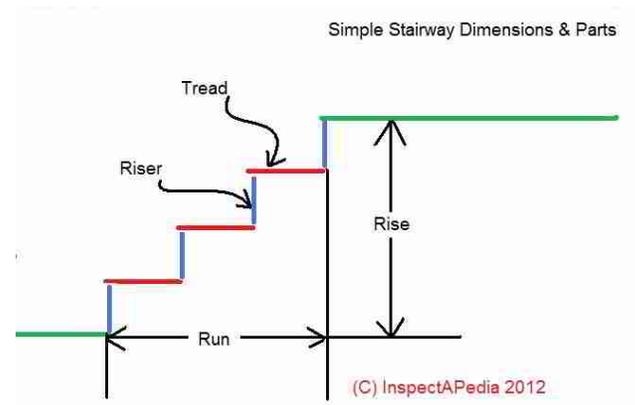
Building Stairs Instructions

Because more people are injured by trips and falls than other hazards, experts have looked closely at the specifications for stairs, steps, and rails to reduce the falling hazards. This work has been translated into stair and railing specifications that are similar among codes and countries (but not identical). -- IBC, IRC, BOCA, Kingston NY Stair Code, & other sources. The International Residential Code 2009 allows up to a 7¾-inch rise and a minimum 10-inch run, with the stipulation that all risers and treads be within ⅜ inch of each other.

Definitions

Stairway Run: the run of a stairway is the *total horizontal distance* traveled by a walker using the stairs, from the first riser to the last riser.

Stairway Rise: the rise of a stairway is the *total vertical height* of a stairway between the walking surface just before the first stairway tread or step up and the beginning of the horizontal walking surface reached at the top of the stairs.



Stair Treads: The stair tread is the horizontal walking surface (red arrow) of an individual step. The tread depth is measured from the forward edge of the step nose or edge of the step above out to the leading edge of the step being measured. Stair tread depths shall be 11 inches (279 mm) minimum.

Specifications - 2013 California Residential Building Code R311.7 Stairways

R311.7.1 Width

The minimum clear width of the stairway at and below the handrail height, including treads and landings, shall not be less than 31 ½ inches (787 mm) where a handrail is installed on one side and 27 inches (698 mm) where handrails are provided on both sides.

R311.7.3 Vertical rise

A flight of stairs shall not have a vertical rise larger than 12 feet (3658 mm) between floor levels or landings.

R311.7.5.1

- **Step riser specifications riser height** (≤ 7.75) maximum and 4 inches (102 mm) minimum. This means your stair risers should be less than or equal to 7 3/4 inches. No taller. Some codes specify slightly taller stair risers, from 8" to 8 1/4"
- **Step riser height uniformity** ($\leq 3/8$ " variation) - this means that more than 3/8 of an inch in variation of the height of steps from one step to another is a tripping hazard.
- **Step riser slope** (out of vertical) (≤ 30 deg measured from horizontal surface of the tread) - this stair specification means the rather obvious hazard that if stairs are pitched or sloped users are more likely to trip and fall. Outdoor stairs that are exposed to wet or icy conditions are an even more serious falling hazard if the stairs are sloped.
- **Step stair riser openings:** open stair risers are permitted provided the opening will not pass a 4" sphere (child safety). This 4-inch opening dimension has the same basis as the rule that requires that the opening between stair balusters must be 4" or smaller.

R311.7.5.2 Treads.

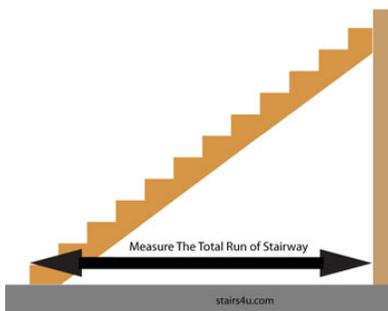
The minimum tread depth shall be 10 inches (254 mm). The tread depth shall be measured horizontally between the vertical planes of the foremost projection of adjacent treads and at a right angle to the tread's leading edge. The greatest tread depth within any flight of stairs shall not exceed the smallest by more than 3/8 inch (9.5 mm).

Building a Stairway

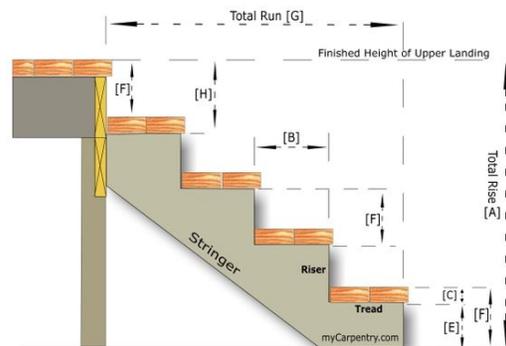
Building Basic Stair Stringers (run time 3:55)

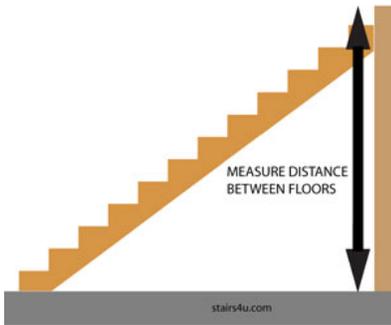
<https://www.youtube.com/watch?v=TDs-x0VPP5w>

How to Figure and Calculate Stair Stringers



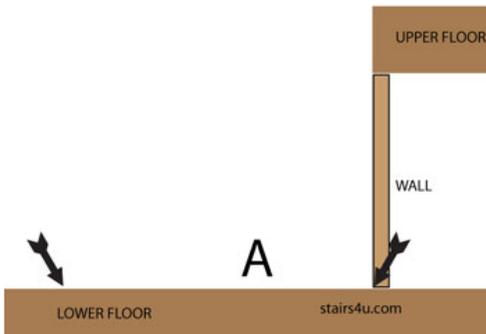
The first thing you will need to do, is measure the total run or horizontal distance of the stairway.





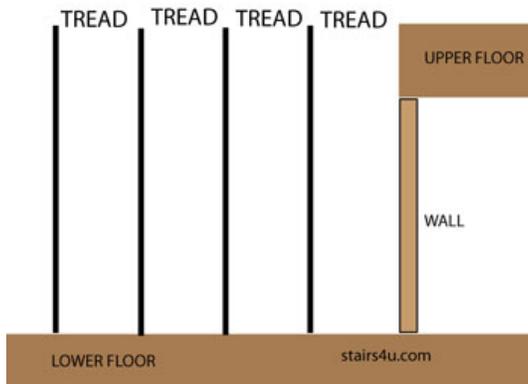
Next you will need to measure the total distance between floors. Simply extend a measuring tape down through the stairway opening in the upper floor and measure the distance between the surface of the upper floor or level and the surface of the lower floor or level. That will be the total rise.

How to Figure and Calculate Stair Treads



The first thing you need to do is get the stair run measurement or the horizontal length of the stairway. Distance A will represent 40 inches. In other words, the distance between the wall supporting the upper floor and the front of the first step will be 40 inches.

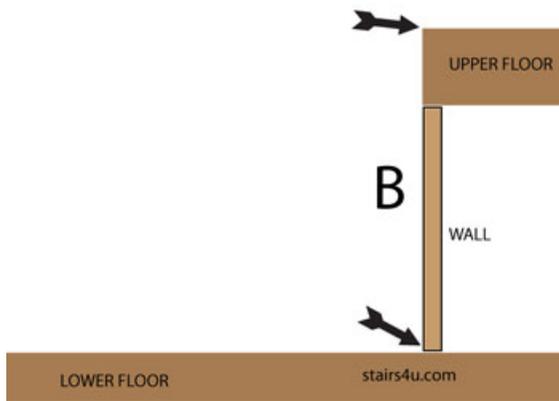
The next step is relatively simple, all you need to do is divide the amount of treads you have into measurement A or the total horizontal distance of the stairway.



If you divide four treads into the total overall horizontal stairway measurement of 40 inches, you will end up with four individual stair treads at 10 inches each.

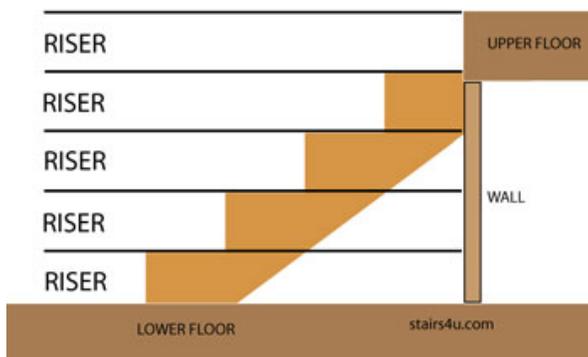
Stair tread and step measurements need to be in equal proportion and the same size; otherwise you could create safety problems, for anyone using your stairway.

How to Figure and Calculate Stair Risers



The first thing you need to do when figuring out the length of your individual stair risers, will be to measure the overall vertical height of the stairway.

Simply measure the distance from the top of the lower floor, to the top of the upper floor. Carpenters and stair builders often refer to this distance as the total stair rise.



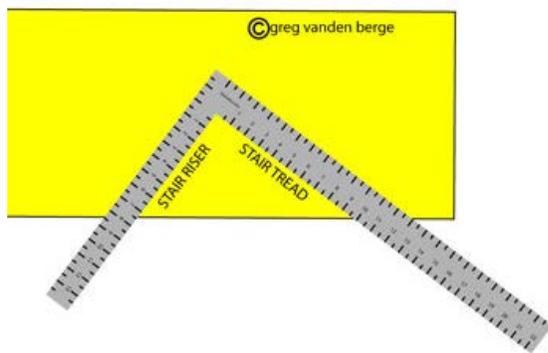
In order to figure out the individual stairway risers, all you need to do is divide the total amount of individual risers into the overall vertical height or stair rise measurement.

For example, if the total stair rise is 35 inches and we have five individual risers, all you would need to do is divide five into 35, to find the overall individual riser height. 5 divided into 35 equals 7

Each individual riser for our example will be 7 inches and

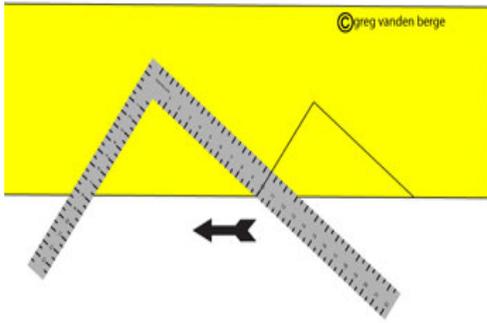
if you need to double check this measurement, simply multiply the overall individual riser height, by the total number of risers. 7×5 equals 35. It's always good to double check every measurement you can, while building stairs.

How to Layout and Mark Stair Stringer



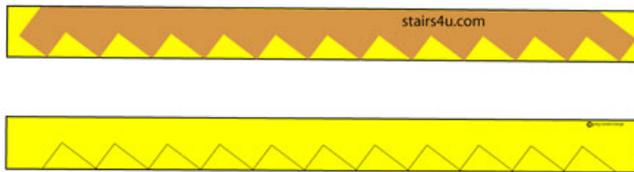
Set up the framing square. As you can see in the illustration, the right side of the framing square will be used to layout the stair treads and the left side of the framing square, the stair risers. In this example, we will be using a 10-inch stair tread or step and a 7 1/2-inch riser. You will be using the calculations you arrived with, after figuring out and calculating your own stair treads and risers. After you have lined up the framing square

with the 10-inch mark on the right side and the 7 1/2 inch mark on the left side of the framing square, with the edge of the 2 x 12, you can mark your first lines for the treads and risers.



The next step will be to slide the framing square to the left, to line it up with the stair tread mark on the framing square. The measurement mark on the framing square that represents your stair tread must line up with the previous mark you made for the riser. Continue lining up the framing square as shown in the steps previously and continue marking the treads and risers, while working your way to the end.

By the time you're finished marking every tread and riser, you should end up with something that looks like the illustration below. Remember, if you only need five treads or steps, then only layout five treads.



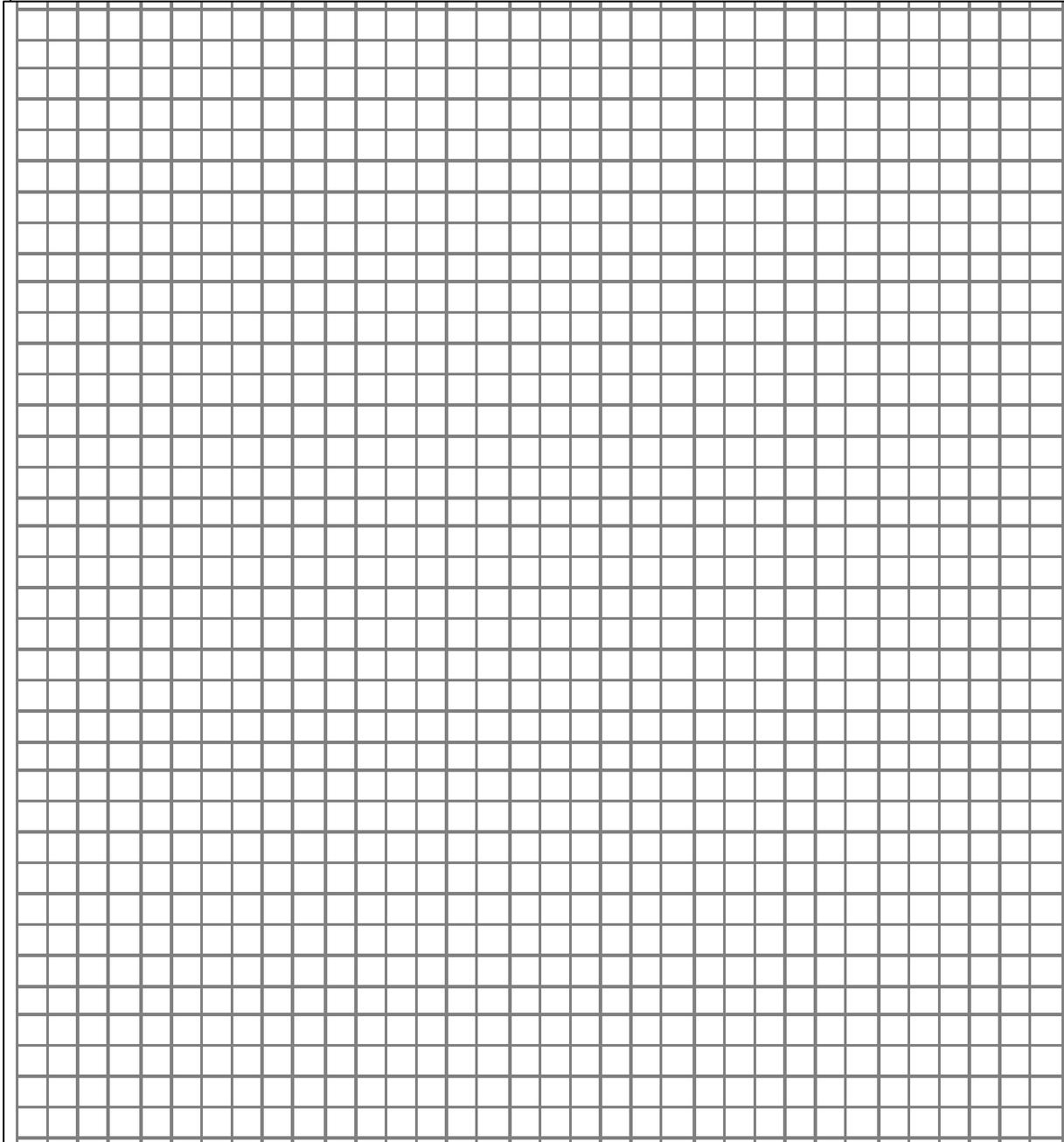
Proposal

Job Name _____

Location _____

Date _____

We hereby submit specifications and estimates for:

A large rectangular area filled with a fine grid of small squares, typical of graph paper, intended for drawing or calculations.

Pet Stairs Project

Planning and Design

When sketching some quick plans for building the dog step keep the following in mind:

- Maximum rise and runs for the steps according to 2013 California Residential Building Code.

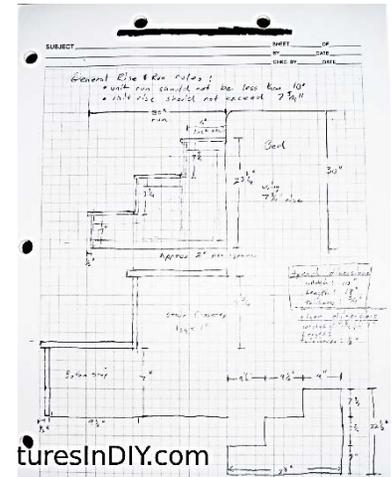
Making the Sides and Cutting the Sides

- The sides are made from some 1/2-inch thick plywood.
- Rise and Run Marked – comply with Building Code

Interior Supports

For the interior support structure for the pet / dog steps.

- 2 x 4s were resized to 1.5-inch x 1.5 inch.
- This yielded two pieces from one 2 x 4.



Installing Back Piece and Toe Kicks

Once everything was framed out a back piece of scrap plywood was cut to cover the back.



Pet Stairs Project Self-Evaluation

1. What I had learned from this project ...

2. Parts of the project I am most proud of ...

3. Safety practices I have been observing...

4. What I have learned that I should be doing, from this point on, to ensure any other projects have an excellent outcome.

Bill of Materials

Part #	Description	Material Type	Dimensions (calculate footage)		Footage (bd/ft, lin/ft, sq./ft)	Quantity Of Parts	Unit Cost	Total Cost
				=				\$-
				=				-
				=				-
				=				-
				=				-
				=				-
				=				-
				=				-
To calculate board feet with all measurements in inches:							$\frac{T \times W \times L}{144}$	Total Cost: \$-