MEASURING AND MARKING DEVICES

INTRODUCTION

Measuring and marking devices are some of the most important tools used in the mechanized agriculture program. With the proper use of measuring and marking devices, projects exhibit quality craftsmanship. Rules, tapes, squares, and marking devices are as important as any other hand tool when properly used. Scribers, dividers, vernier calipers, metal rules, and micrometer calipers are necessary tools for measuring and marking metal. Standard linear measurements in construction work are the foot, inch, and fraction of an inch. Measuring tools are usually marked into graduations of one foot, one inch, one-half inch, one-fourth inch, one-eighth inch, and one-sixteenth inch. Steel squares may be graduated by one-tenth and one-twelfth of an inch. The machinist’s rule is 4 to 6 inches in length and is graduated from 1 inch to 1/64 inch. There are steel rules that are graduated into 10ths or 100ths of an inch. Precise measurements are made with micrometers, where measurements can be made in thousandths of an inch. The area or volume of a construction project is determined by the use of measuring devices. Materials are purchased according to units of measure determined with a measuring device. Materials are sold by using a device to determine the size of the materials needed. Lumberyards, hardware stores, and supply stores usually have measuring tools on hand for in-house use.

The system of measuring length that uses inches and feet is called the English system*. Many parts of the world use the metric system. The metric system uses a base of 10, and a decimal system to indicate fractions. In the metric system, the basic unit of length is the meter. A meter is 39.37 inches, slightly more than one yard. The tool for measuring length in the metric system is called a meter stick. A meter stick is graduated into centimeters and millimeters. A centimeter is 1/100th (0.01) of a meter. A millimeter is one-tenth of a centimeter, and 1/1000th (0.001) of a meter. Meters can be subdivided into decimeters - 1/10th of a meter (0.1), and ten meters make a decameter. The metric unit of length that correlates to English miles is a kilometer, which is 1,000 meters. Fractions of a kilometer are expressed with decimals, such as 0.7 km, which is 7/10 of a kilometer or 700 meters. You can always determine the relative size of a metric unit by its prefix.

COMMON METRIC PREFIXES

<table>
<thead>
<tr>
<th>Prefix</th>
<th>Symbol</th>
<th>Fraction</th>
<th>Decimal</th>
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<tbody>
<tr>
<td>Kilo</td>
<td>k</td>
<td>One thousand</td>
<td>1,000</td>
<td>$10^3$</td>
</tr>
<tr>
<td>Hecto</td>
<td>h</td>
<td>One hundred</td>
<td>100</td>
<td>$10^2$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>One</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Centi</td>
<td>c</td>
<td>One one-hundredth</td>
<td>0.01</td>
<td>$10^{-2}$</td>
</tr>
<tr>
<td>Milli</td>
<td>M</td>
<td>One one-thousandth</td>
<td>0.001</td>
<td>$10^{-3}$</td>
</tr>
</tbody>
</table>

* Underlined words are defined in the Glossary of Terms.
COMMON TYPES OF SQUARES

Framing Square

The framing square is a tool used for measuring the spacing of rafters, studs, and joints. A standard framing square is L-shaped with a 24-inch by 2-inch body (blade) and a 16-inch by 1-1/2 inch tongue. The blade and tongue arrangement forms a right angle. Each inch is divided into several graduations. The outside edge of the face is graduated in 1/16 inch and the inside 1/8 inch. The outside edge on the back is graduated in 1/12ths, the inside tongue 1/10ths, and the blade 1/16ths. Some framing squares may also have pilot hole tables or other useful features.

Some uses of the square are:

a. When measuring the width of a board, place the blade edge even with the board edge and read the measurement on the tongue. The square should be used with the face up. Length may be measured along the blade.

b. To properly square a board, place the inside edge of the square blade on the edge of the board and mark along the tongue.

c. When checking a board for squareness, place the inside blade edge along the board edge and the tongue on the end edge.

d. Another major use of the framing square is simplified somewhat by a table shown on the blade. There is a rafter and framing table on the face of the blade.

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In order to use this table properly, certain terms must be understood and used. The following drawing illustrates roof framing terminology.

![Diagram of roof framing terminology]

a. The **pitch** of a roof is the slope or ratio of rise to width of the building (the rise is divided by twice the run). For example, for a run of 14 feet and a rise of 7 feet the pitch is \(\frac{1}{2}\) (7 divided by 2 x 14). If the rise is 6 feet, 8 inches and the run is 10 feet, the pitch is \(\frac{1}{3}\) (6’ 8” divided by 2 x 10).

b. **Span** is the distance from one outer plate edge to the other outer plate edge.

c. **Run** is half the distance of the span on equal pitched roofs. It is the distance from the outer edge of the plate to the center of the ridge.

d. **Rise** is the distance from the top of the plate to the highest point on the measuring line (work line on a rafter).

A simple way to lay out common rafters is by using the “stepping method.” Inch marks are used on the blade and tongue of the square. The length of the rafter per foot of run is determined by the pitch of the roof. For example, a \(\frac{1}{4}\) pitch (6 inches rise per foot of run) is calculated in inches per foot of run. The distance from the 6-inch point on the blade to the 12-inch point on the tongue equals 13.42 inches. This number is found on the first line below the 6-inch mark on the blade. If the building has a run of 14 feet at \(\frac{1}{4}\) pitch, then the rafters will be of the following length:

\[
13.42'' \times 14 = 187.88 \text{ divided by } 12 = 15.65 \text{ feet}
\]

The 12-inch measure is used on the blade and 6-inch measure on the tongue when laying out this rafter. It is necessary to make 14 steps from the plumb cut to the end of the bird’s mouth (notch to fit plate) to complete the full length (15.65 feet) of the rafter.
Hip and valley rafters are stepped off in the same manner except that the 17” mark on the blade is used instead of the 12” mark.

The Essex measure is found on the backside of the blade. The starting point is the 12-inch graduation on the outer scale. It represents a board 1 inch thick and 12 inches wide. For example, to find the board feet in a board 1 inch thick, 8 inches wide, and 14 feet long use the following procedure.

Go to inch number 13, look down to find the dimension 1X8, and find the number .67. This represents the number of board-feet in a piece of lumber 1 inch thick, 8 inches wide, and 1 foot long. Multiply the number .67 by 14 feet (length) to find that there are 9.38 board feet in a board 1 inch thick, 8 inches wide, and 14 feet long. To find the number of board feet in 2-inch thick lumber, multiply your answer by two.

The brace measure table is found on the backside of the tongue. Three numbers are grouped together at intervals. The pair of numbers, one over the other, is a measurement of the legs of right angles. The third or more prominent number is the diagonal measurement, or hypotenuse. Example:

The brace run on a stud and a beam is 54 inches; therefore, the brace will be 76.37 inches at the longest points on the 45-degree cuts.
Combination Square

The major parts of a combination square are the face, head, and blade. The head is equipped with a spirit level and a scriber (small scratch awl). Blades may be several different lengths, but the 12-inch blade is most commonly used. The head has a 90- and 45-degree angle to the blade. It is attached to the blade by a slot in the blade’s center and the head can be moved up or down on the blade by properly adjusting the head screw. The blade is graduated in thirty-seconds, sixteenths, and eighths of an inch.

A combination square can be used as a marking gauge, an inside/outside square, a miter square, or a level.

Combination squares may also be used as depth gauges and plumb gauges. With a center head attachment, the square can be used to locate the center of round objects. With a bevel-protractor head, angles can be marked in degrees. The blade can be used to measure short lengths.

Try Square

The try square most commonly used has a 6-inch blade, and the handle is not used for measuring. The blade is usually graduated into one inch, one-half inch, one-fourth inch, and one-eighth inch measurements. Actually, the blade length may vary from 6 to 12 inches. This square is similar to the framing square in that the handle and blade form a 90-degree angle. It is used mainly to measure and square narrow or small materials, and to check the accuracy of cuts.
**Speed Square**

The speed square has many of the same uses as the framing square, with the exception of figuring board feet of lumber. The speed square does not have an Essex table. Speed squares come in a variety of sizes, and are generally made from aluminum or high-impact plastic. Each square comes with a manual for laying out rafters, stairs, and other applications. Speed squares are popular due to their size and ease of use.

**COMMON TYPES OF RULES AND TAPES**

**Bench Rule**

A bench rule is 36 inches long and 1 1/4 inches wide. This rule is graduated in sixteenths of an inch on one side and eighths of an inch on the other side. The rule can be used as a straight edge, and a steel bench rule is usually thin enough to mark a gentle curve or arc.

**Vernier Caliper**

The vernier caliper has several very important uses. It is used mainly to take accurate measurements of width and diameter. Board thickness, hole diameter, and bolt size are just a few of the applicable uses of vernier calipers. There are two measurement scales on the lower jaw. One scale is for reading outside measurements, and the other is for reading inside measurements. Do not make outside measurements on cylinders that have a greater depth radius than the jaw opening. Make the measurement correctly by reading the graduation on the sliding rule that is in line with the line on the stationary jaw.

**Retractable Push - Pull Tape**

The push - pull tape, or tape measure, is the most common measuring device used in construction. Retractable tapes are available in many lengths, ranging from 8 to 30 feet. Smaller tape measures are available if needed. Only one side of the tape is numbered; but both edges of the numbered side are graduated in sixteenths of an inch. Some tapes are graduated in thirtyseconds of an inch for the first foot. Retractable tapes are equipped with a hook or clip on the end so that they can be secured for measuring.
Use the tape measure for layout work and measuring objects. Curved or irregular surfaces may be measured with the tape due to its flexibility. Inside measurements (doorjamb to doorjamb) can be made, and 2 to 4 inches can be added for the length of the case. Tape measures are generally marked in sixteen-inch and twenty-four inch intervals as well. This makes measurements for framing walls easier. The tape measure is easily carried in a pocket or on a tool belt.

**Measuring Tapes**

Measuring tapes are made in 50, 100, and 200 feet lengths. One side of a measuring tape is graduated in one-eighth inch increments, and one-tenth inch increments are used on the other side. These tapes are used to make long measurements such as laying out foundations, landscape designs, and in some cases surface measurements. The tape may be made of spring steel or fiberglass. Steel tapes are coated with nylon or Teflon to prevent rust. These tapes are equipped with a ring or hook at the beginning of the tape to allow one-person use. Measurements are read from the tip of the ring. These tapes are very useful in squaring building foundations.

**HOW TO READ A TAPE MEASURE**

On project plans, the symbols ‘(apostrophe) and “(quotation mark) are often used. In construction, ’ means feet, and “ indicates inches. A dimension of 25’ 11 ¾” is read as twenty-five feet, eleven and three-quarter inches. Sometimes the ‘ may be left off and the measurement is written as 11 – 2 ½”, or eleven feet, two and one-half inches. Construction dimensions are not generally given in yards since materials are purchased by the foot.

Tape measures are divided into feet and inches. On a tape measure, each inch of length is marked with several lines of varying lengths. Generally, the longest line is in the middle of an inch. This is the half-inch mark, and there is only one. The next shortest lines are the quarter-inch marks – there are two; one on each side of the half-inch mark. The third-shortest line is the eighth-inch mark – there are four marks, one on each side of each quarter-inch mark. The next shortest line is the sixteenth-inch mark – there are eight of these, located on each side of the eighth-inch marks. Construction work does not use the precision of one thirty-second of an inch. For reference, the kerf of a circular saw is approximately 1/8” wide.

The smallest unit of measurement on most tape measures is one sixteenth of an inch (1/16”). There are fifteen marks and sixteen spaces between two-inch marks. One inch is 16/16ths of an inch long. Fractional numbers are always expressed in the largest unit possible, so we say something is one inch long, not 16/16ths long. When measuring an object, set the inch mark at the beginning of the object and count the lines. If the object measures five short lines, the measurement is 5/16”. If an object measures eight short lines, the measurement is 8/16” or ½”, a half-inch, using the least common denominator.
OTHER MARKING AND READING DEVICES

Using Dividers and Trammel Points

The wing divider is used in construction work to make circles, transfer short measurements from a rule, scribe arcs and circles, and divide measurements into equal parts. Dividers can generally measure from 4 to 10 inches between points. The divider is a useful instrument for stepping off measurements of both rise and run when cutting rafters. The divider is different from a compass in that both legs of a divider are solid.

DIVIDERS

Trammel points are usually attached to a straight piece of board or a metal rod. They are used to make circles that are too large to be made by a compass or divider.

Chalk Lines

Another important marking device used in construction is the chalk line. One end of the line is hooked over a nail or other type of fastener at the layout point, and the line is chalked, as it is unwound toward the second layout point. The line is held or tied at the second point before it is snapped to the surface. Chalk lines are useful for laying out long cut lines on sheets of plywood, paneling, oriented-strand board, etc.
**Equal Parts Layout**

Standard lumber cuts are usually in fractions of an inch; therefore, measurements are made in a special way to make equal board cuts.

Rules or squares of different types may be used to find the center or even parts of a board. For example, to find the center of a board that is 5-1/2 inches wide, the end of a rule can be placed on one edge and the 6-inch mark placed on the other edge. The rule will be at an angle on the board, but a mark at 3 on the rule will be the center. Marks at 2 and 4 on the rule will divide the board into three equal parts. Odd numbers can be determined by dividing the number by the desired number of pieces.

**USING PLANE GEOMETRY TO SQUARE PROJECTS**

The right-angle method is often used to square the corners of large projects such as trailers, storage buildings, and foundations. This is also called the 3:4:5 method, and is a very simple application of the Pythagorean theorem.

To square one corner of a trailer frame, use the following procedure:

- a. Tack the two pieces of the frame at a right angle. Mark point A at the end corner of the long side of the frame.
- b. Measure 4' from point A along the length of the frame and mark point B. (AB)
- c. Measure 3' from point A along the width of the frame and mark point C. (AC)
- d. From point B, measure with a push-pull tape until the 5' mark crosses point C. This length is the hypotenuse. If the 5' mark does not align with C, adjust the short piece (AC) until the marks align. When the marks align, the angle at point A is a true right angle (90°).
- e. Tack the corner joint in a second spot and re-check the measurements. If the 5’ mark from B aligns with point C, weld the joint securely.
- f. Repeat this process for each of the other corners of the frame.

Based on the Pythagorean theorem, the mathematics for these dimensions are $3^2 + 4^2 = 5^2$, or $9 + 16 = 25$. As long as the 3:4:5 ratio is maintained, the angle at A will always result in a right angle and the project will be square. If you are constructing a small greenhouse with sides of 16' and 9', the hypotenuse will be 25'.

For more information about calculating areas, refer to IMS video #9715 “Measurement: Area and Perimeter.”

(For measuring and marking activities related to your SAEP, refer to IMS #RB-221, Activities for Agricultural Science 221. After completing an activity, be sure to record the entry in the journal page of your Internet record book, and click on 221-B for the Course and Unit of Instruction.)
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REFERENCES


RELATED WEB SITES

Conversions and Equivalents
Measurement Quiz
The Wood Zone

www.infoplease.com/ipa/AO873852.html
www.funbrain.com/measure/index.html
www.woodzone.com

GLOSSARY OF TERMS

Arc – A portion of a circle.

Bird’s mouth – The part of a rafter that goes above the plate.

English system – The system of measuring length that uses inches, feet, and yards, and utilizes fractions such as 1/4, 1/2, 1/8, etc.

Hypotenuse – In geometry, the side of a right triangle directly opposite the right angle, or the longest side of a right triangle.

Kerf – The cut made by a saw blade.

Metric system – A numbering system that counts in units of tens and utilizes decimal fractions, such as 0.1, 0.01, 0.001, etc.

Pitch – The slope or ratio of a roof’s rise to the width of the building.

Pythagorean theorem – The geometric theorem stating that “the square of the hypotenuse of a right triangle is equal to the sum of the squares of the two adjacent sides.”
Rise – The distance from the top of the plate to the highest point on the measuring line.

Run – The distance from the outer edge of the plate to the center of the ridge.

Span – The distance from one outer plate edge to the other outer plate edge.

SELECTED STUDENT ACTIVITIES

MULTIPLE CHOICE: Place the letter of the correct answer in the space provided at the left of each number.

___ 1. Measuring tools used in carpentry are graduated as
   a. 1/16 inch.
   b. 1/32 inch.
   c. 1/64 inch.

___ 2. The blade or body of a standard framing square is
   a. 1-1/2 inches by 16 inches.
   b. 2 feet by 2 inches.
   c. 18 inches by 2 inches.

___ 3. Where are the rafter and framing table located on a framing square?
   a. the backside of the tongue
   b. the face side of the blade
   c. the backside of the blade

___ 4. Half the distance of a span on equal pitched roofs (plain gable) is known as
   a. the run.
   b. the pitch.
   c. the rise.

___ 5. What square is equipped with a spirit level?
   a. try
   b. framing
   c. combination
   d. speed

___ 6. What rule is most commonly used to take inside dimensions (doors and windows)?
   a. push-pull tape
   b. bench rule
   c. measuring tape

___ 7. What rule is best suited for measuring hole widths?
   a. bench
   b. push – pull
   c. measuring tape

___ 8. The main use of trammel points is to
   a. transfer measurements from a rule.
   b. divide measurements into equal parts.
   c. make circles.
9. List four major uses of a framing square.
   a. ____________________________________________________________
   b. ____________________________________________________________
   c. ____________________________________________________________
   d. ____________________________________________________________

10. What are the three tables found on the tongue and blade of a framing square?
    a. ____________________________________________________________
    b. ____________________________________________________________
    c. ____________________________________________________________

11. Define the following terms.
    Pitch _________________________________________________________
        __________________________________________________________
    Rise _________________________________________________________
        __________________________________________________________
    Span _________________________________________________________
        __________________________________________________________
    Run _________________________________________________________
        __________________________________________________________
    Bird’s Mouth ________________________________________________
        __________________________________________________________

12. What are four uses of the combination square?
    a. ____________________________________________________________
    b. ____________________________________________________________
    c. ____________________________________________________________
    d. ____________________________________________________________

13. List two types of measuring rules.
    a. ____________________________________________________________
    b. ____________________________________________________________

14. How is the wing divider used in construction work?
    ____________________________________________________________________
    ____________________________________________________________________
    ____________________________________________________________________
    ____________________________________________________________________
PROBLEM SOLVING: Solve each problem in the space provided. Show all your work.

15. What is the pitch of a standard gable roof if the width of the building is 32 feet and the rise is 8 feet?

16. How long is a rafter for the building in problem 7?

17. How many board feet are there in 8 pieces of 1” x 8” x 10’? Use the Essex board measure table.

18. How long is a brace if the stud and beam measurements are 57 inches? Use framing square table to find the answer.

19. What is the easiest way to divide a 1” x 8” board into three equal parts? List the correct numbers on the rule and indicate the numbers that are used to divide the board into three equal parts.

20. Using a meter stick, give the actual metric dimensions of the following pieces of lumber:
   a. a 2x4 X 16” long
   b. a 1x4 X 8” long
   c. a 2X2 X 12” long
   d. a 2X12 X 4’ long
   e. a full sheet of 3/8” plywood
   f. a half-sheet of 1/2” particle board
   g. a quarter-sheet of 5/8” wafer board sheathing
21. What is the pitch of a roof that has a 5’ rise and a 15’ run?

22. What is the roof pitch of a building with a 40’ span and having a 4’ rise?

23. What is the pitch of a roof with a 28’ run and 7’ rise?

24. What is the roof pitch on a building with a 55’ span and having a 5’ rise?

25. Using a tape measure, give the actual dimensions of the following pieces of lumber to the nearest 1/16”:
   a. a 2x4 X 16” long
   b. a 1x4 X 8” long
   c. a 2X2 X 12” long
   d. a 2X12 X 4’ long
   e. a full sheet of 3/8” plywood
   f. a half-sheet of 1/2” particle board
   g. a quarter-sheet of 5/8” wafer board
26. Place the answers to questions #20 and #25 in the table below for comparison.

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<tr>
<th>Lumber</th>
<th>English Dimensions</th>
<th>Metric Dimensions</th>
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</tr>
<tr>
<td>2X12</td>
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<td></td>
</tr>
<tr>
<td>3/8&quot; plywood</td>
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<td></td>
</tr>
<tr>
<td>1/2&quot; particle board</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5/8&quot; wafer board</td>
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</tr>
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</table>

ADVANCED ACTIVITIES

1. Use the 3:4:5 methods to square a large piece of work.
2. Develop a table of common 3:4:5 measurements for barns and greenhouses.
3. Cut out and demonstrate common types of triangles using plywood or other materials.
4. Make a large-scale ruler that demonstrates 1/2”, 1/4”, 1/8”, 1/16”, and 1/32” graduations.
5. Make a large-scale ruler that demonstrates the metric system for measuring length.
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