After studying this chapter, you should be able to:

• Distinguish between measuring, marking, and layout tools.
• Lay out lines and geometric shapes.
• Transfer shapes to working material.
• Maintain measurement and layout tools.

Accurate measurement and layout is essential for high quality cabinetmaking. You must be able to transfer the shapes of your design onto your materials. With skillful measuring, you can mark, cut, and assemble parts with precision.

Much of cabinetmaking relies on square edges and joints. Squareness simply means that all corners join at a 90° angle. See Figure 12-1. When a piece is not cut square, or two pieces are not assembled square, the entire cabinet is affected.

This chapter describes how to mark accurate geometric shapes on your materials. A number of tools are used by cabinetmakers to complete layouts. These include marking, measuring, and layout tools.

12.1 Marking Tools

Most cabinetmakers mark with pencil. A sharp pencil will make an accurate line. Remove pencil marks with an eraser before sanding. A knife or scratch awl (scriber) will also mark the wood. See Figure 12-2. A light cut makes a visible reference line for sawing or other work. A knife is often used when the mark is needed to locate a tool, such as a saw or chisel. A scratch awl can indent the wood to help center a drill. See Figure 12-3. Avoid ink because it bleeds into wood cells.

12.1.1 Marking Gauge

Traditionally, cabinetmakers used a marking gauge to layout their cuts. The marking gauge is designed to make parallel lines. It has an adjustable head and a steel pin or cutting wheel, Figure 12-4. It is used to mark parallel lines on wood, plastic, and metal.

Measuring tools are instruments used to determine lengths and angles. They follow two systems. They are the US customary system and the International System (SI), commonly referred to as metric. US customary rulers and scales measure feet and inches. Smaller units are measured in fractions of an inch. See Figure 12-6A. To find the fractional distance you need, count the spaces across the board. This becomes the numerator (top number). Count the spaces in one inch on the rule. This is the denominator (bottom number). You can also use a marking gauge to transfer dimensions. Set the marking gauge to the size of part you wish to copy. Then mark the new workpiece. This is helpful when duplicating parts.

12.2 Measuring Tools

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Metric rulers and scales measure in millimeters. They are typically numbered every 10 mm. See Figure 12-6B. A metric rule may be further divided into 0.5 mm. Both systems may appear on the same measuring tool, as shown in Figure 12-6C.
The measuring system you choose depends on the working drawings. The title block will indicate what system is used. It will also provide the scale of the drawing. If the scale reads 1″ = 1′-0″, then each inch on the drawing will be 1′ on the layout.

Special purpose rules include a centering rule, with the measuring units extending both directions from the center zero point. This reduces the chances for error with many centering tasks. Rigid folding rules are usually 6′ long. Metric folding rules are 2 meters long. Some have an extension rule at one end for measuring inside distances and depths. See Figure 12-7.

A flexible rule, or tape measure, is very convenient and will measure both straight lengths and curves. See Figure 12-8. It can also be used to measure inside distances, such as a doorway. To account for the size of the tape case, add the distance indicated on the side of the case to your measurement. Most tape cases will be printed with the amount you must add (usually 2″–3″). Some tape measures have a window on the top to read the inside distance.

The rule you select depends on the accuracy you need and which style you prefer. Rules may be flat, flexible, or folding types. They are made of wood, fiberglass, plastic, metal, or cloth. Sometimes both customary and metric measurements are found on the same rule. Flat rules are typically metal, wood, or plastic. They may be 12″ to 48″ long. High quality wood rules have brass ends. The brass ends are not damaged as easily as wood. Rules may also be steel or aluminum.

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and a 16″ (406 mm) tongue that form a 90° angle (right angle). A bench square is smaller. See Figure 12-11.

The face of the square is seen when the body is held in the left hand and the tongue in the right hand. The back is the other side of the square. The face and back of both squares have measurement scales and most framing squares also have tables.

Try squares have a steel blade and a steel or wood handle. Some have a 45° angle cut into the handle. Try squares are the most reliable of all squares for accuracy. Use them for making layouts, checking square-ness, or setting up machinery. See Figure 12-12.

A combination square is more versatile than a try square. It consists of a grooved blade that slides through the handle. It can also be equipped with a protractor and a center head. See Figure 12-13.

You can use a combination square for a number of purposes:
• Measure distances and depths.
• Lay out 45° and 90° angles.
• Draw parallel lines.
• Locate centers.

To lay out a parallel line, adjust the blade to the intended distance. Place a marking device such as a pencil, scratch awl (from the handle on some squares), or knife point against the end of the blade. While holding the marking device against the blade, slide the square down the material. See Figure 12-14A.

Many combination squares have a center head. Hold it against any circular or curved surface. The blade’s edge will point directly through the center of a circle, Figure 12-14B.

The protractor head adjusts for any angle. You may wish to remove the handle and center head when using the protractor head. See Figure 12-14C.

Tables provide helpful information for commonly used measurements. Two such tables are the brace measure table and the octagon, or eight-square scale.

The brace measure table gives diagonal measurements that show the length needed for a diagonal piece, such as a brace, to support a shelf. The measurements are on the tongue of most framing squares, Figure 12-15. For example, suppose you have a 22″ wide shelf and you wish to brace it at a point 18″ from the wall and 24″ below the shelf. Find the measurement on the table marked 18/24. You will find the number 30 next to it. This is the proper length of the brace.

Using an Octagon Scale
The octagon scale helps you identify critical measurements for laying out octagons. Suppose you wanted to create an octagon tabletop 28″ across, Figure 12-16. To produce this tabletop, proceed as follows:
1. Cut a piece of material 28″ square.
2. Draw centerlines AB and CD.
3. Set a compass or divider for 28 dots along the octagon scale.
4. Mark the distance on each side of the centerlines along the four edges of the board.
5. Connect the newly marked locations to form the eight sides.
The scales refer to customary and metric measurements. This makes the square useful as a tool. Once a measurement is marked, the square can be used to draw a perpendicular line. See Figure 12-17. It can also be used to check the squareness of an assembly.

12.2.5 Scales

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12.3 Layout Tools

Layout tools transfer distances, angles, and contours. Most lack scales for measuring distances and angles. These are set with a measuring tool. The following descriptions cover common layout tools.

12.3.1 Sliding T-Bevel

The sliding T-bevel is used to lay out and transfer angles, Figure 12-18. Set the angle of the T-bevel with a protractor. Loosen the locking device on the handle to move the blade. After setting the proper angle, tighten the locking device.

Besides layout, T-bevels can set the angles for table saw blades, jointer fences, and drill press tables. If you are setting 90° angles, use a try square. T-bevels are not as accurate as a square.

12.3.2 Angle Divider

An angle divider is a layout tool consisting of two blades that move outward at an equal rate from the body. It is used to bisect angles. The blades move apart from 0° to 90°. If the blades are adjusted to an angle or a corner, the body bisects the angle. This angle helps when cutting miter joints. See Figure 12-19A.

Angle dividers have numbers on the body and an index mark on the adjusting nut. The numbers on the side of the nut are 30°, 45°, and 60°. Accurately aligning the index mark along these numbers sets the blades to that angle. The numbers on the other side of the nut are 4, 5, 6, 8, 10, and 0. These indicate settings for polygons. Aligning the index nut at 6 will set the angle of the blades for a hexagon (a six-sided polygon). The angle between the blades will be 120°. The body will bisect the angle at 60°. When the index mark is set at 0, the blades form a straight line with the body.

12.3.3 Calipers

Calipers are used to transfer dimensions. The three types of calipers are outside, inside, and hermaphrodite. See Figure 12-20. Some are assembled with a firm (friction) joint. Others have a bow spring with an adjusting screw and nut. Firm-joint calipers are quicker to adjust, but bow-spring calipers maintain greater accuracy during use.

Figure 12-14. Use the combination square to complete these tasks. A—Mark parallel lines. B—Find centers. C—Mark angles.

Figure 12-15. The brace measure table shows brace lengths.

Figure 12-16. The octagon scale, found on some framing squares, is a row of numbered dots for laying out octagons.

Figure 12-17. Framing and bench squares are used for measuring, marking, and checking squaresness.

Figure 12-18. The T-bevel has a body, blade, and locking device. A—Setting the angle with a protractor. B—Marking the wood.

Figure 12-19. Angle dividers are helpful when setting angles for cutting miter joints.
Calipers are used most often when wood turning. When the lathe is stopped, you can check or transfer thicknesses and distances. An outside caliper checks outside diameters on turnings. See Figure 12-21. First, set the caliper with a rule. Then turn the material until the caliper slips over it. When making duplicate parts, set the caliper by the workpiece being copied.

**Inside Caliper**

An inside caliper checks inside diameters. Preset the caliper with a scale. Then turn the work until the diameter is reached, Figure 12-22.

The tools described thus far measure and mark distances, lines, and angles. You will also need to lay out circles, arcs, and curves. Tools used for these purposes include compasses, dividers, irregular curves, and profile gauges.

**12.3.4 Compass and Divider**

Compasses and dividers are similar layout tools. Both have two legs. However, a compass has a pencil point on one leg instead of a steel point. See Figure 12-24. Use compasses and dividers to:
- Step off distances.
- Bisect lines, angles, and arcs.
- Construct lines and arcs tangent to each other.
- Scribe circles, ellipses, and arcs.
- Lay out polygons.
- Cope contours, such as for fitting moulding.

Marking with a compass requires some hand coordination. Place one hand on or near the top (joint) of the compass or divider. See Figure 12-25A. The other hand sets the pivot location of the steel point.

Use compasses and dividers as you would when drafting. Adjust the compass or divider to the proper measurement when transferring distances, Figure 12-25B. Then mark the material. You can also duplicate parts by setting the dividers to the size of the original part and use them to mark the new material.
12.3.5 Trammel Points

Trammel points are used for making large circles and arcs. Two steel points are clamped on a rectangular piece of lumber. See Figure 12-26A. Some have a point that can be replaced with a pencil. This allows you to mark the wood with either a pencil mark or a scratch.

The size of the circle is limited only by the length of wood you choose for the points to slide on.

12.3.6 Profile Gauge

A profile gauge is used to copy irregular shapes. See Figure 12-27. Press it against a curved surface. This causes individual pieces of wire or plastic to slide. Once shaped, the contour can be transferred to a pattern, paper, or the material to be cut.

12.4 Layout Practices

Layout must be done with accuracy. Although layout tools can be used many ways, select the tool that is best suited to your work.

12.4.1 Marking Points

When marking a distance, the best pencil mark to make is an arrow or V. See Figure 12-28. The point of the arrow shows the proper location. A pencil dot may be lost among the scratches or blemishes in the wood. A short line does not tell which end of the line is the proper measurement. When making the mark, do not press hard. Remember, any pencil marks, dents, or scratches you make during layout must be removed later. Erase all unnecessary pencil marks.

Procedure

Laying Out a Circle with Trammel Points

To lay out a circle with trammel points:
1. Adjust the points to the desired radius with a rule.
2. Hold one steel point of the trammel at the center of the circle.
3. Swing the other trammel point in an arc to mark the circle on the material, Figure 12-26B.

12.4.2 Lines

Most lines are made using a rule or square. For lines that must be parallel to the edge, use a marking gauge, combination square, or hermaphrodite caliper.

12.4.3 Circles and Arcs

Compasses, dividers, and trammel points make accurate circles and arcs. To set them, place one leg on the 1″ mark of a rule. Adjust the other leg according to the desired measurement. Remember, be sure to account for starting away from the end of the rule.

Arches are partial circles. The arc has a center point and radius. Set the layout tool for the radius of the arc. Then locate the point of the tool at the arc’s center and swing the desired arc.

12.4.4 Polygons

Common polygons include triangles, squares, rectangles, hexagons, and octagons. Polygon shapes are used for a variety of items including tabletops, mirror and picture frames, and clock faces.

Two common tools used to lay out polygons are the framing square and protractor. Set angles on the framing square using two pieces of wood and the measurements on the tongue and body. See Figure 12-29.
Some cabinet styles have irregularly shaped parts. For example, Early American furniture has many curves. Working drawings usually include patterns that show how to lay out the shape. For example, square grid patterns are a way to transfer complex designs from working drawings to material. Make two square grid patterns. One pattern is traced over the working drawing and cut out. The other pattern is a full-size pattern. The size of grids should correspond to the scale of the working drawing. If the scale is \( \frac{1}{4} \text{ in} = 1 \text{ in} \), use a \( \frac{1}{4} \text{ in} \) grid sheet. The full-size transfer pattern will be 1 in squares.

### Procedure

**Laying Out an Ellipses with a String**

An ellipse (oval) can be laid out easily with a string. Figure 12-32. Select a string that will not stretch, and proceed as follows:

1. Cut out a rectangle the desired size of the ellipse.
2. Make centerlines EF and GH.
3. Make an arc using point B as the pivot and line BC as the radius.
4. Measure the length of line AD.
5. Divide that distance by two. \( \frac{AD}{2} \)
6. Measure this distance on each side of O to locate points I and J.
7. Put thumbbacks or small nails at points E, I, and J.

**Patterns**

Drawings may provide full, half, or detail patterns. Figure 12-33. A **half pattern** shows detail on one side of a centerline. You mark around the pattern, then turn it over and mark again. A **detail pattern** may be necessary for more complex shaped parts.

A **square grid pattern** is a way to transfer complex designs from working drawings to material. Make two square grid patterns. One pattern is traced over the working drawing and the other is a full-size pattern. The size of grids should correspond to the scale of the working drawing. If the scale is \( \frac{1}{4} \text{ in} = 1 \text{ in} \), use a \( \frac{1}{4} \text{ in} \) grid sheet. The full-size transfer pattern will be 1 in squares.
Make the grid on tracing paper placed over your working drawings. Then trace the shape from the working drawing, Figure 12-34A.

Cut a sheet of heavy wrapping paper for the full-size pattern. Lay out the proper size squares on the paper. Place a dot on the pattern grid where the design crosses it. See Figure 12-34B. Connect the dots to complete the full-size pattern. Cut out the pattern with scissors. Then lay the pattern on the wood and trace around it.

**Templates**

A template is a permanent full-size pattern used for guiding a tool. For example, you may lay a template over material to guide a router bit to cut out a shape. It may be made of cardboard, hardboard, or thin sheet metal. Make a template when you intend to use the shape several times. When duplicating irregular curves, use a profile gauge. Refer again to Figure 12-27. This is much simpler than trying to measure the original part to make the pattern.

**Layout Rod**

A layout rod is a record of often-used distances. Plan to make one for standard cabinets you produce. It eliminates the need to measure repeatedly with a rule. A layout rod can also help with machine setups.

The rod is marked with important cabinet dimensions, Figure 12-35. These may be the location of shelves, doors, and joints. Measurements are marked full size. Make the rod slightly longer than the greatest dimension of the cabinet. The rod can be used for height, width, and depth measurements.

A rod is made of 1 × 1 or 1 × 2 lumber. It is surfaced on all four sides. One side may contain width measurements. A second side may contain height measurements. Other sides are used for depth and other important dimensions.

**Story Pole**

Similar to a layout rod, a story pole is used to mark the exact locations of items found in a room. It is usually made of 1 × 3 lumber and is as long as necessary (up to the room width). A second pole is made equal to the height of the room, or the top of the highest cabinet. In addition to marking cabinet locations on the story pole, mark all other items in the room, such as electrical outlets, switches, doors, windows, vents, radiators, plumbing, and light fixtures.

**Digital Measuring Devices**

There are many digital measuring devices available. Lasers are now commonly used on jobsites for measurement. They can be used to quickly and accurately record the dimensions of a space. Electronic calipers can switch from inch to metric with the push of a button. See Figure 12-36. Machine accuracy and repeatability is now so precise that cabinet-makers frequently measure to within thousandths of an inch.

As parts are created, they must be measured to ensure accuracy so assemblies will fit together properly. Some digital measuring devices have the ability to send data to a computer for collection. See Figure 12-37. This record of parts in production can help resolve any machining issues that may occur.
12.6 Measuring and Layout Tool Maintenance

Measuring and layout tools need very little maintenance. There are few moving parts. However, care is needed during handling and storage of the tool.

Some measuring tools, such as framing and try squares, have scales stamped on them. They may become difficult to read over time. If so, wipe across them with a cloth containing white paint. Then remove the excess from the surface of the tool with steel wool. The measurements should be readable again.

Many tools are plated or painted to prevent rust. If rust does occur, such as on the blade of a try square, remove it with steel wool. Then rub the blade with paste wax. Oil should be used sparingly with woodworking tools because it can stain wood.

Moving joints should be rubbed with paste wax for lubrication. However, be careful when lubricating firm-joint tools, such as calipers. This might cause the joint to move too freely.

Knives and awls require sharpening. Refer to Chapter 39 for tips on sharpening. The points on dividers, compasses, trammel points, and marking gauges may need to be touched up occasionally.

Safety in Action

Measuring and Laying Out Workpieces

When measuring and laying out workpieces:
- Hold sharp points of tools away from you when carrying them.
- Cover sharp tool points if you must have them in your pocket.

Figure 12-36. Digital measuring tools are capable of recording inside, outside, diagonal, hole-edge and hole-hole dimensional measurements.

Figure 12-37. This measurement table is used to check and record panel measurements. These can be uploaded to a computer.
Suggested Activities

1. Make a list of measuring tools and machines with measuring scales in your shop. List the units these tools and scales have (US customary, metric or a combination of both). Are there times when one measurement system is preferable to the other? Share this list with your instructor.

2. Lay out an octagon using the octagon scale on a framing square. Show your construction to your instructor.

3. Using an angle divider or T-bevel, divide a 90° angle into 15° increments. Share your drawing with your instructor.

4. Following steps listed in this chapter, lay out a hexagon and an octagon using a compass. Show your finished construction to your instructor.

5. Use the grid method to enlarge a 1/4 scale irregular layout to actual size. Share the finished drawing with your instructor.