Manual Drafting Tools and Equipment

Unit: Media, Equipment, and Reproduction Methods

Problem Area: Manual Drafting

Lesson: Manual Drafting Tools and Equipment

Student Learning Objectives.

Instruction in this lesson should result in students achieving the following objectives:

1. **Name common manual drafting tools.**
2. **Describe how manual drafting equipment is used.**

Resources.

The following resources may be useful in teaching this lesson:

E-unit(s) corresponding to this lesson plan. CAERT, Inc. http://www.mycaert.com.

"Drafting Tools-Manual Drawing," *Quizlet*. Accessed Dec. 17, 2018. https://quizlet.com/633549/drafting-tools-manual-drawing-flash-cards/.

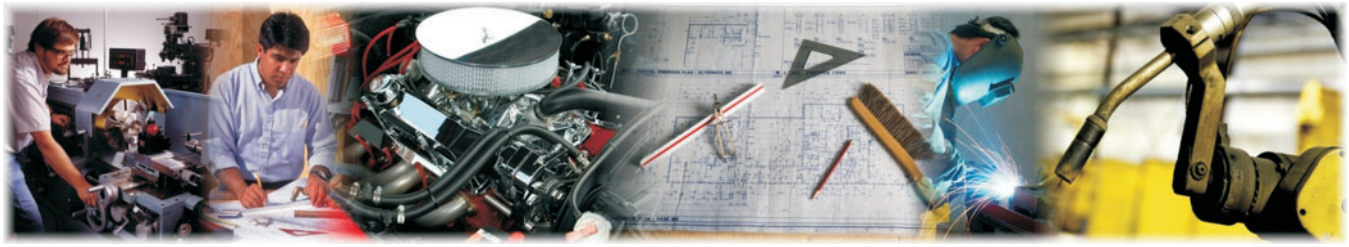
Guilmette, Mike. "How to Use a 30-60-90 Drafting Triangle," *Sciencing*. Accessed Dec. 17, 2018. https://sciencing.com/use-306090-drafting-triangle-8654265.html.

"Manual Drafting Techniques," *Designing Buildings Wiki.* Accessed Dec. 17, 2018. https://www.designingbuildings.co.uk/wiki/Manual_drafting_techniques.

Shalu. "Manual Drafting Tools for Engineering Drawing," *Scribd*. Accessed Dec. 17, 2018. https://www.scribd.com/presentation/105497766/Manual-Drafting-Tools-for-Engineering-Drawing.

Stewart, David. "Hand Drafting vs. CAD," *Techwalla*. Accessed Dec. 17, 2018. https://www.techwalla.com/articles/hand-drafting-vs-cad.

Stott, Rory. "The Computer vs The Hand In Architectural Drawing: ArchDaily Readers Respond," *ArchDaily*. Accessed Dec. 17, 2018. https://www.archdaily.com/627654/the-computer-vs-the-hand-in-architectural-drawing-archdaily-readers-respond.



Equipment, Tools, Supplies, and Facilities

- ✓ Overhead or PowerPoint projector
- ✓ Visual(s) from accompanying master(s)
- ✓ Copies of sample test, lab sheet(s), and/or other items designed for duplication
- ✓ Materials listed on duplicated items
- ✓ Computers with printers and Internet access
- ✓ Classroom resource and reference materials

Key Terms.

The following terms are presented in this lesson (shown in bold italics):

- adjustable curve (flexible curve)
- drafting
- drafting board
- drafting compass
- drafting table
- drafting triangle
- drafting vellum
- dusting brush
- erasing shield
- French curve
- irregular curve
- lead holder
- manual drafting
- mechanical pencil
- parallel straightedge
- protractor
- scale ruler
- straightedge
- T-square
- technical drawing
- technical pen
- technical pencil
- template

Interest Approach.

Use an interest approach that will prepare the students for the lesson. Teachers often develop approaches for their unique class and student situations. A possible approach is included here.

> *Display technical drawings created by hand (manual drafting). Explain that manual drafting is considered an art form in which one develops the skill and precision to create perfectly straight and squared lines, line weights, and details by hand. In Chicago, a city known for its architecture, a majority of the*

architectural firms have clients for whom they redraw (for renovation or updating) original technical drawings of skyscrapers, homes, and public buildings. For most of these original manual drawings, no CAD drawings exist. Two examples of early 1900s architectural drawings created with manual drafting tools and equipment may be viewed at https://commons.wikimedia.org/wiki/File:Easy_steps_in_architecture_and_architectural_drawing_(1915)_(14784027823).jpg and https://commons.wikimedia.org/wiki/File:Proposed_new_office_building_for_the_Queensland_National_Bank_Limited,_Creek_Street_(architectural_drawing),_Jul,_1906_(24941183594).jpg.

CONTENT SUMMARY AND TEACHING STRATEGIES

Objective 1: Name common manual drafting tools.

Anticipated Problem: What are common manual drafting tools?

I. Manual drafting tools

Drafting is the creation of technical plans that are used to determine how architectural and mechanical structures should be built. ***Manual drafting*** is the practice of creating drawings by hand, with pencil or ink on various mediums, including paper and film. CAD (computer-aided drafting) evolved from advanced manual drafting techniques. A ***technical drawing*** is a sketch, illustration, or diagram that visually communicates how something works or is constructed. The term "technical drawing" may be used in place of the word, "drafting." Drafters use manual means and CAD software to convert the designs of engineers and architects into technical drawings. Manual drafting equipment ensures that those drawings are precisely drawn.

A. PENCILS: A drawing pencil is used to sketch and each type is classified by lead softness or hardness. For the purpose of sketching, many drafters use a common pencil in a range from 2H to 2B. Technical pencils are used to finalize a sketch.

1. *Lead*: Lead grades may be hard (9H, 8H, 7H, 6H, 5H, 4H), medium (3H, 2H, H, F, HB, B), or soft (2B, 3B, 4B, 5B, 6B, 7B). A hard lead is used to draw light, thin lines, such as lettering guidelines and light construction lines. A medium lead is commonly used to draw thick lines on mechanical and architectural drawings. Soft leads are too soft to be effective in mechanical drafting. They are typically used for artwork.
2. *Mechanical pencils*: A ***mechanical pencil*** (***lead holder***, ***technical pencil***) is a hand tool, constructed from plastic or metal materials, that holds fine, replaceable lead. By twisting the outer casing of the lead holder, the pencil

lead may be extended as the point is worn away. A lead holder is the more traditional version of mechanical pencils. A drafter can change out the graphite or lead to achieve different line weights and thicknesses. All the leads come in one standard thickness but have a range of graphite softness or hardness that is utilized for different line weights. Many drafters use the modern mechanical pencil or automatic pencil that can be purchased at any office supply store. Leads are available in different thicknesses and specific sizes so that they do not need to be sharpened. The thickness designation is the same as is used for technical ink pen tip sizes, but mechanical pencils do not have the same full range of sizes.

B. PENS: A ***technical pen*** is a specialized inking tool, used to make lines of constant width on technical drawings. They have fine grading diameters to control line width. They are available in a range of tips from very thin to very thick. Pen tips are connected to a reservoir of ink and are extremely precise and often expensive. Precision pens have replaced technical pens and can be purchased at most office supply stores. Precision pens, with built-in "precision" tips, can be used for sketching or drafting on any drafting media. They are inexpensive, come in a range of sizes, and require little maintenance. Precision pens are less precise than technical pens and the ink quality is inferior. Precision pens may not be reused.

C. ERASERS: Special erasers for manual drafting are available at art stores and online. Drafters, creating a final technical drawing, use specially designed erasers. Some erasers are called kneaded, plastic, or stick. Depending on the intended use, erasers may be soft or hard. Erasers are designed to remove ink, graphite, and plastic leads. An ***erasing shield*** is a thin metal or celluloid plate, with openings of several sizes and shapes, that confines an erasure to a limited area. It ensures that only an exact portion of a line is removed. A ***dusting brush*** is a hand tool, made from very soft fibers, used to remove any erasure debris. It also reduces the chance of the drafter's hand smudging or smearing the drawing.

D. DRAFTING TABLES AND BOARDS: A ***drafting table*** is a work surface that is adjustable for height and angle of incline. These tables have a variable pitch top placed atop a rigid leg-support structure. A ***drafting board*** is a pitched tabletop with perfectly squared corners and a flat surface. Most manual technical drawings are created on drafting vellum. ***Drafting vellum*** is smooth, translucent paper, made from plasticized cotton, that remains unaffected by changes in temperature or humidity. Drafting vellum is available in rolls, pads, and sheets.

E. STRAIGHTEDGES: A ***straightedge*** is a drafting tool, made of metal, plastic or wood, that is used to draw a straight line. T-squares, scale rulers, parallel straightedges, and drafting triangles are types of straightedges.

1. A ***T-square*** is a ruler with a short crosspiece that slides along the edge of the drawing board as a guide for making straight, parallel lines.
2. A ***scale ruler*** is a three-sided ruler, used to convert between scaled drawings and the actual dimensions without making mathematical calculations. It is used by architects and readers of blueprints to reduce or enlarge a drawing.
3. A ***parallel straightedge*** (parallel ruler) is a tool consisting of two straightedges, connected by pivoted crosspieces of equal length that ensure that both

straightedges are parallel to each other at all times, although the distance between the straightedges may vary. A parallel straightedge is used primarily as a guide on a drafting table. It helps the drafter to draw straight and precise lines that are parallel to each other. It can be an expensive instrument and is fastened to both sides of the drafting board with thin wire. The wire holds the straightedge perfectly parallel to the bottom of the board allowing the drafter to move it straight up and straight down. A parallel straightedge is often considered the most important instrument in manual drafting.

4. A ***drafting triangle*** is a precision tool for drawing lines at specific angles, usually constructed of transparent plastic that allows the drafter to see the drawing underneath the tool. A drafting triangle always has one right angle at 90°. They are used in combination with a T-square or straightedge to draw vertical and angled lines. A standard 30°-60°-90° triangle has angles of 30°, 60°, and 90°. A standard 45° triangle has angles of 45° and 90°.

F. DRAFTING COMPASS: A ***drafting compass*** is a metal device consisting of a horizontal beam and two vertical legs, used for drawing and measuring circles and arcs. One leg is sharp and one leg holds the pencil, lead, or inking pen. Drafting compasses have a range of adjustments and attachments that allow them to create very small to very large circles.

G. FLEXIBLE CURVE: A ***flexible curve (adjustable curve)*** is a long, bendable ruler, that may be fixed in position to form and hold a smooth curve. Its form can be adjusted to produce any curved line.

H. FRENCH CURVE: A ***French curve*** (an ***irregular curve***) is a template, with various edges and swirls, that allows a drafter to draw and connect curves together so that they are perfectly fitted together.

I. PROTRACTOR: A ***protractor*** is a tool for laying down and measuring angles; typically a flat semicircle, marked with degrees along the curved edge. It is usually made of clear plastic to ensure marks are exact. Protractors create accurate and precisely angled lines with a straightedge that can be pressed along a T-square or parallel rule.

J. TEMPLATE: A ***template*** is a flat piece of plastic with standard symbols cut in it, used when symbols (denoting such things as electrical elements, plumbing elements, fixtures, etc.) are to be drawn repeatedly. Templates are available in a range of sizes or scaled shapes, usually at specific increments. Shapes include circles, ellipses, squares, and triangles.

Teaching Strategy: *Many techniques can be used to help students master this objective. Use VM–A, VM–B, and VM–C to illustrate common drafting tools. Then, display and demonstrate any drafting equipment and tools students will need to complete a manual-drafting project.*

Objective 2: Describe how manual drafting tools and equipment are used.

Anticipated Problem: How are drafting tools and equipment used? How are drafting tools and equipment maintained?

II. Manual drafting equipment guidelines

Manual drafting equipment guidelines help ensure clean and accurate drawings that are created efficiently. Manual-drafting equipment should be used properly and be properly maintained to ensure accurate, sharp and clean drawings.

A. PENCILS: Whether traditional lead holders or modern mechanical pencils, it is important to ensure that the pencil draws a consistently thick line. The grading system for lead applies to both lead holders and modern pencils.

1. *Mechanical Pencils*: Lead holders (traditional mechanical pencils) have tips that must be constantly sharpened to maintain the proper thickness. However, constant sharpening can result in excess graphite powder that may smear onto the drawing. To ensure that a lead tip is a constant thickness, it is twisted in the fingers as a line is drawn. If not twisted while drawing, the lead quickly flattens out along a single line. To produce the required effect, leads need to be changed out for each different line weight. Lead holders are still commonly used but they can be time consuming and messy. Modern mechanical or automatic pencils are used like any other pencil. They contain more than one lead at a time. They do not need to be sharpened and are much quicker and cleaner to use than lead holders. The lead for modern mechanical pencils comes in the exact thickness desired.
2. *Grades of Lead*: Pencil leads come in grades that range from hard to soft. The softer the lead, the darker the line it produces. The harder the lead, the lighter line it produces. Each grade has a number and letter designation similar to common pencils. Hard grades have a letter H plus a number. Higher numbers equal a harder grade: 9H is the hardest, to 2H the softest. Soft grades have a letter B plus a number. Higher numbers are the softer grades: from 2B up to 7B+ (the softest). Medium grades are given a letter only: F, HB, and B. However, the standard medium range usually includes several numbers in addition to the letters H or B. The common yellow school pencil is a 2B.

B. TECHNICAL PENS: A technical pen is held at a 90° angle (perpendicular) when drawing onto paper or film. Holding at any other angle may cause ink to leak and/or for the surface to be scratched by the tip. Ink requires time to dry and the drafter must wait before drawing over or around recently drawn lines. Technical pens are rarely used for manual drafting of technical drawings. They are commonly used for artistic drawings that take a lot of time. Technical pens must be cleaned each time they are used. Tips that are not regularly cleaned will clog, will not create accurate line weights, and may "bleed" onto the drawing. Precision pens require no cleaning and do not need to be held at a 90° angle to the drafting media surface. The tips of precision pen tips are delicate. To avoid breaking the tip, care should be taken when pressing the tip to the paper.

C. ERASERS: Hard erasers may be used to remove graphite or inked lines. They tend to erase more thoroughly than soft erasers, especially for ink. However, they can scratch the drawing surface if not used carefully and will leave residue on the drawing. Eventually they need to be replaced. Soft erasers leave as much residue as a hard eraser. They can last a very long time and do not scratch the drawing surface. A soft eraser can be used to "pick up" small particles of graphite. An erasing shield allows the user to remove a very specific portion of a line by locating it in the cutouts. Erasures can leave particles and smears on a technical drawing. When drawing by hand, the use of a dusting brush helps ensure a clean and clear surface. The brush's soft fibers brush away any leftover particles without smearing.

D. DRAWING BOARDS: A drawing board must be perfectly square to create accurate and parallel lines. The drawing surface must be composed of a completely smooth material to ensure that a pen or pencil does not "dip or slide" into a surface depression. Historically, drawing boards were composed of a thin, hard, smooth rubber mat. Drafting tape is used to adhere and secure a drawing to the board. Today, most drafting, design, and engineering offices keep a few simple boards for sketching.

E. STRAIGHTEDGES: Parallel straightedges and T-squares with a thin lip along the sides are recommended rather than those with an edge of a constant thickness. An edge of constant thickness may cause ink to bleed or cause graphite to smear. In practice, an edge with a thin lip does not actually touch the drawing and that keeps the drawing clean. Clean straightedges and T-squares prevent smudges on the drawing. A parallel straightedge should be routinely checked for accuracy. A drafter should draw several horizontal lines at different increments and the measure their distance to each other. The distance should be the same across entire line. A T-square is routinely checked in the same manner. When using a T-square the top of the "T" should always be pressed firm to the drawing board to ensure that lines are properly perpendicular or parallel to each other.

F. TRIANGLES: Triangles can be used in combination with other triangles to create less common angles. One edge of the triangle is always pressed firmly to a straightedge or T-square. When using an adjustable triangle, it is important that the lock or knob is tight and set at the correct angle. Then, the adjustable arm moves easily when a pen or pencil is pressed against it and, just like a straightedge or a T-square, triangles with a thin lip edge are recommended. If a triangle does not have a thin edge, it can be raised by several levels of tape to keep the drawing clean. Triangles should be cleaned regularly.

G. DRAFTING COMPASSES: A drafting compass can be used to create arcs, curved lines, and combinations of both. A compass is held at about 70° to the board when drawing. It takes some practice to be able to spin it accurately and develop a good technique. Some compasses can be cumbersome to properly twist in a full circle. Complex compasses have many arm adjustments and screws that can accidently be turned or pushed. Before drawing, a drafter must patiently read through any instructions to ensure that all adjustments are correct.

H. CURVES: An adjustable curve is easy to adjust and bend and holds its position well once the correct shape is formed. They are used to create random lines or even wavy lines and should be cleaned after each use to keep graphite from smearing a drawing. While useful for drawing clean curved lines that change their direction or size, A French curve can be time consuming to use. A drafter must make points on the drawing and use the curve in several different positions to create a desired curved line. It does not have exact arcs or any specific radius along its curves. A drafter must make several sketches along different paths to create a desired curve. A French curve should be cleaned regularly to prevent smudges and smears on technical drawings.

I. TEMPLATES: Templates are used for common symbols that must be drawn multiple times. They are available for all drafting professions and are prepared in the drawing scales typically used by the profession. Some templates have small spacers that allow it to be raised slightly above the drawing to keep the surface clean and to avoid ink from bleeding under the template. Templates are cleaned regularly to avoid smudges and smears on a technical drawing.

Teaching Strategy: *Many techniques can be used to help students master this objective. Have the students create a series of basic drawings to learn how to use the manual drafting equipment and tools available in your lab. Then, assign LS–A.*

Review/Summary.

Use the student learning objectives to summarize the lesson. Have students explain the content associated with each objective. Student responses can be used in determining which objectives need to be reviewed or taught from a different angle. Questions at the ends of chapters in the text book may also be used in the Review/Summary.

Application.

Use the included visual master(s) and lab sheet(s) to apply the information presented in the lesson.

Evaluation.

Evaluation should focus on student achievement of the objectives for the lesson. Various techniques can be used, such as student performance on the application activities. A sample written test is provided.

Answers to Sample Test:

Part One: Matching

1. c
2. a
3. h
4. g
5. d
6. b

7. f
8. e

Part Two: Completion

1. drafting vellum
2. drafting triangle
3. drafting compass
4. T-square
5. 70°
6. parallel straightedge
7. twisted (or twisted around)
8. precision

Part Three: Short Answer

Parallel straightedges and a T-squares with a thin lip along the sides are recommended rather than those with an edge of a constant thickness. An edge of a constant thickness can cause ink to bleed or cause graphite to smear. In practice, an edge with a thin lip does not actually touch the drawing and that helps keep the drawing clean.

Sample Test

Name _____

Manual Drafting Tools and Equipment

Part One: Matching

Instructions: **Match the term with the correct definition.**

a. drafting
b. erasing shield
c. manual drafting
d. mechanical pencil
e. straightedge
f. technical drawing
g. template
h. technical pen

_____1. The practice of creating drawings by hand, with pencil or ink on various mediums, including paper and film

_____2. The creation of technical plans that are used to determine how architectural and mechanical structures should be built

_____3. A specialized inking tool, used to make lines of constant width on technical drawings

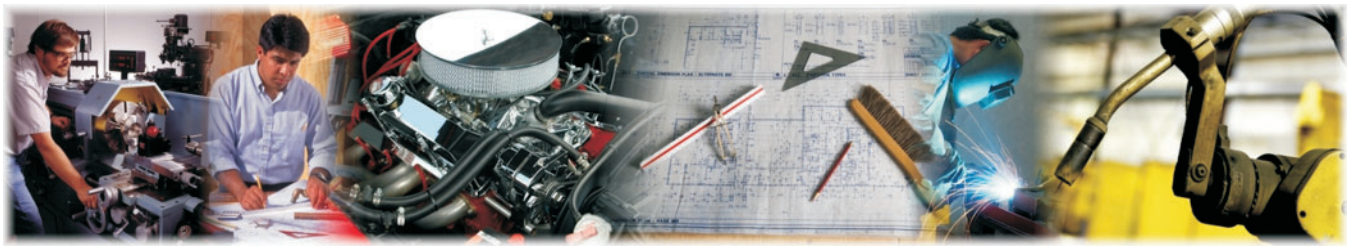
_____4. A flat piece of plastic with standard symbols cut in it, used when symbols (denoting such things as electrical elements, plumbing elements, fixtures, etc.) are to be drawn repeatedly

_____5. A hand tool, constructed from plastic or metal materials, that holds fine, replaceable lead

_____6. A thin metal or celluloid plate, with openings of several sizes and shapes, that confines an erasure to a limited area

_____7. A sketch, illustration, or diagram that visually communicates how something works or is constructed

_____8. A drafting tool, made of metal, plastic or wood, that is used to draw a straight line



Part Two: Completion

Instructions: **Provide the word or words to complete the following statements.**

1. Smooth, translucent paper, made from plasticized cotton, that remains unaffected by changes in temperature or humidity is called _____.
2. A precision tool for drawing lines at specific angles, usually constructed of transparent plastic that allows the drafter to see the drawing underneath the tool is called a/an _____.
3. A metal device consisting of a horizontal beam and two vertical legs, used for drawing and measuring circles and arcs is a/an _____.
4. A ruler with a short crosspiece that slides along the edge of the drawing board as a guide for making straight, parallel lines is a/an _____.
5. A compass is held at about _____ to the board when drawing.
6. A/An _____ is often considered the most important instrument in manual drafting.
7. To ensure that a lead tip is a constant thickness, it is _____ in the fingers as a line is drawn.
8. _____ pens require no cleaning and do not need to be held at a 90° angle to the drafting media surface.

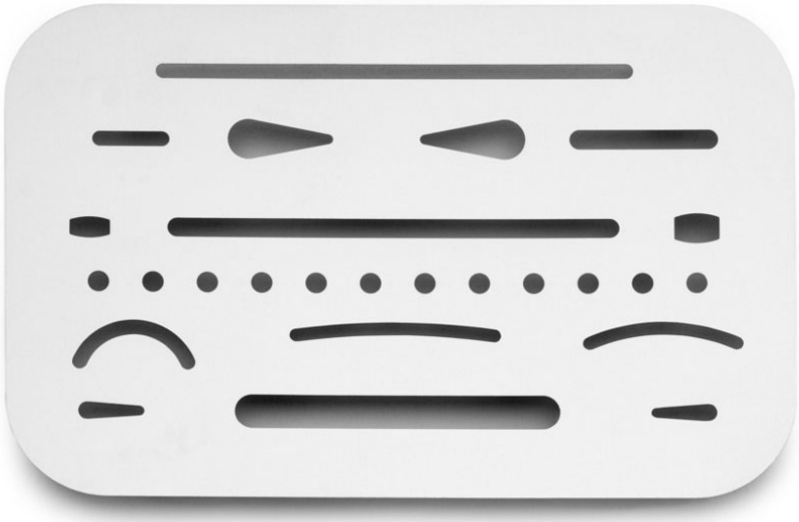
Part Three: Short Answer

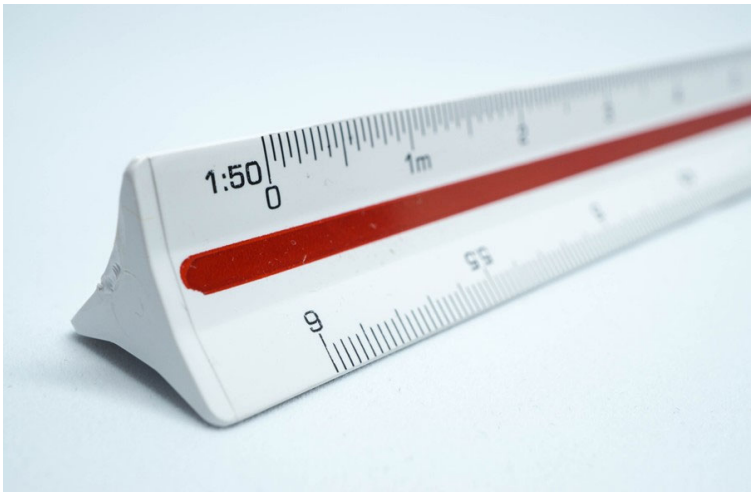
Instructions: **Answer the following.**

Describe how the edges of parallel straightedges and T-squares help keep a drawing clean.

MANUAL DRAFTING TOOLS: PART 1

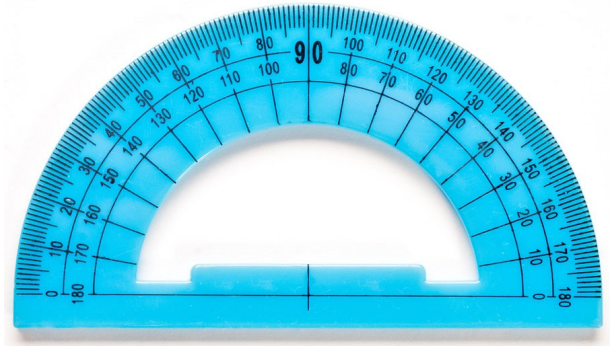
Which manual drafting tools are pictured here?





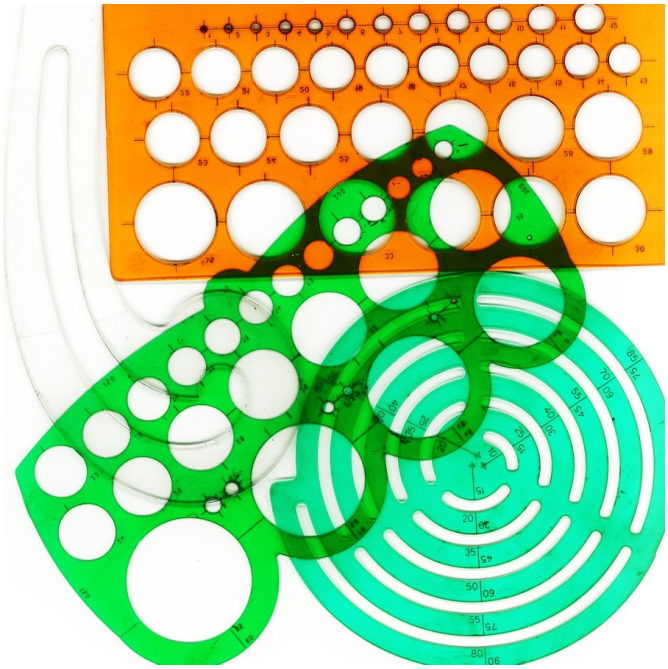
MANUAL DRAFTING TOOLS: PART 2

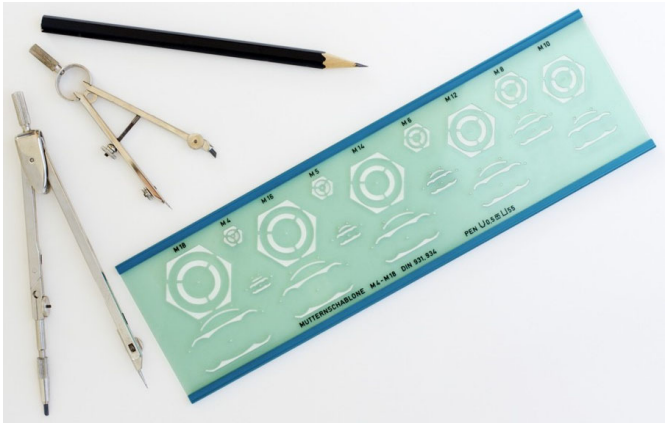
Which manual drafting tools are pictured here?

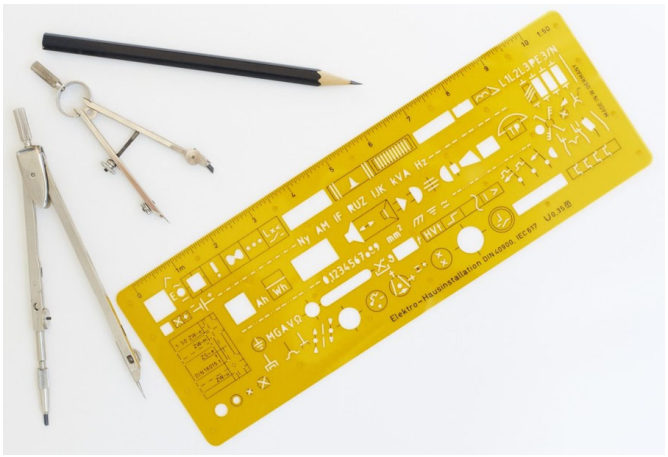


MANUAL DRAFTING TOOLS: PART 3

What is drawn with each of these drafting stencils?







LS–A

Name _____

Create a Technical Drawing Using Manual Drafting Tools and Equipment

Purpose

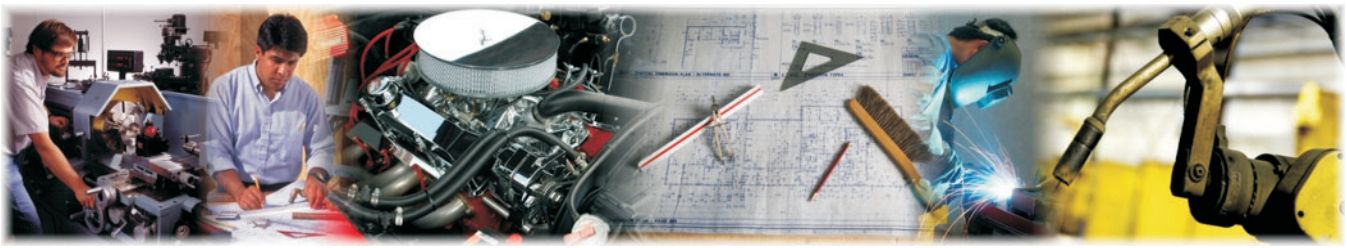
The purpose of this lab is to use manual drafting tools and equipment to create a technical drawing.

Objectives

1. Use manual drafting tools and equipment.
2. Create a technical drawing using manual drafting tools and equipment.
3. Demonstrate knowledge of manual drafting equipment

Materials

- lab sheet
- a drawing board/drafting table
- a parallel straightedge or a T-square
- various triangles
- drafting compass
- adjustable curve or French curve template
- a lead holder with several leads (graphite)
- technical inking pens (several pen thicknesses if available)
- drafting vellum



Procedure

1. Select an object (or objects) to draw with your manual drafting tools and equipment. Architectural, engineered, or manufactured objects are preferred for this assignment.
2. Select a view or elevation of the object that best represents the form.
3. Set up your drawing board/drafting table. Use a T-square or parallel ruler.
4. Draw the object using ink or graphite (as directed by your instructor) and the necessary drafting tools and equipment.
    a. Begin by drawing the main (overall) lines.
    b. Create a reference point for the bottom along a straight line.
    c. Use the techniques mentioned in your reading to ensure the best technical drawing project.
5. Display your drawing.
6. Turn your completed drawing in to your instructor.