Drawings have been used since the beginning of history for planning and producing art objects, architectural designs and engineering works. Since the Industrial Revolution a system for creating architectural and engineering drawings has evolved. While the pens, pencils, tools and papers for creating drawings have changed, the basic forms for presenting information have stayed the same. People doing technical work need to be familiar with the standard ways of presenting design information.

Interpreting information from drawings is an important skill. Engineers and architects must be able to look at a set of plans and mentally picture the shapes of objects. Skilled workers must have the same abilities. Reading a drawing involves a highly developed ability to look at lines on the page and convert the shapes from several pictures to form a three-dimensional mental image.
A Detail part or Working Drawing is shown. Features of the drawing include different views of the part, dimensions, notes, materials and a title block. Drawings like this may be created by manually drawing lines on paper or by computer. The drawing must convey all information needed to produce the part.

Learning to produce drawings like this involves knowing the rules for drawing views of objects, correct dimension choice and placement, correct format for drawing presentation. Many standards exist which tell how to provide correct and consistent information to those who use the drawings.

Reading drawings is the process of looking at the lines that represent the part shapes and mentally picturing the part. This is a very high-level thinking process which requires practice to become proficient.

A pictorial view gives a quick idea of the shape of the part.

Multiple views (Top and Front in this example) are used to show the true shape of the geometry of the part.
Assembly Drawings show the parts used, how the parts are assembled and part identifications. Item numbers from the drawing are referenced in the Parts List or Bill of Materials. This is the first drawing in a set of drawings. It gives an overview of the product and shows how the parts are used.

Assembly drawings are often included with the product for reference. An exploded view may be used to identify parts for replacement and to show how to disassemble and reassemble for servicing.

Special instructions and notes are shown. These pertain to the whole assembly. Many companies use PS or Process Specifications to specify how common jobs are to be performed. Inspection, painting, packaging, etc. may be done in many ways depending on the product. Referencing a PS-number is more efficient than writing a lengthy note on the drawing.

The Assembly Drawing is the first drawing in a set of drawings.
Sketching

Freehand sketches are used by designers to transfer mental images to paper. Ideas are constantly changing as new thoughts occur. Engineers and architects create many sketches to help define the objects or constructions they imagine. Meetings are held to exchange ideas, refine designs and get approvals to proceed with a design.

Words cannot describe three dimensional technical design information accurately. Quick two dimensional or three dimensional sketches clearly represent the shapes of objects and the thoughts of the designers. The ability to sketch quickly and accurately to proportion is an important skill for all technical workers.

Artistic ability is an asset but anyone can learn to sketch by following basic techniques. Engineers and architects frequently use special sketching grids which help keep lines straight and proportional.

All design information and research is archived with drawings for each project. This is necessary for future use in case of failures, lawsuits or patent disputes as well as new projects which grow from the current designs. Very clear, readable sketches and text information is essential.

Words and notes on sketches must be readable. Experienced engineers and architects use block letters - usually uppercase - to assure clarity. Cursive writing is never used as it is often unreadable after sketches and memos are duplicated or faxed to another location. Vertical capital block form letters are preferred.

| BEARING BLOCK DESIGN WITH REPLACEABLE INSERTS |
| A - 4 |

Engineering style vertical capital letters.
Computer drawing has replaced most of the manual drawing work. Until 1985-1990 drawings were made on paper or other media using tools.

.5MM fine lead pencils have become popular replacing the thicker wood and lead-holder type leads. Thicker leads are stronger but require frequent sharpening. Lead hardness grades from 9H to H, F, HB to 6B are available. Select the lead hardness which suits the film or paper being used.

T-squares and drawing boards were used for many years to create accurate drawings. Paper or cloth material was aligned with the t-square and held in place with tacks or tape. Skill was required to keep all the tools in place while drawing.

Parallel rules running on string cables were preferred by many architects. With care the rules would maintain relatively accurate horizontal alignment. Metal or plastic 30-60 degree or 45-45 degree triangles were aligned to draw angles in 15 degree increments.

Drafting machines were popular for machine drafting because the built in protractor allowed the drawing of angles to the closest 5 minutes of one degree. Vertical and horizontal scales reduced the need for triangles.

30-60 and 45-45 triangles are shown below.
Manual Drafting Tools

Compass and divider set. Locking compass helps to maintain setting while making very dark lines.

Circle templates are best for small diameter circles.

An erasing shield helps to do a cleaner job of erasing. Each time the eraser crosses an edge, it creates a fresh eraser surface.

Electric erasers are essential for large jobs.

Irregular curves are needed when special curves must be drawn.

Flexible curves may be bent to precise shapes.

Ink pens are used to draw very sharp black lines.

Precise lettering may be done using lettering guides. This is a slow process but it produces nearly perfect letter shapes.
Drawing Papers - Copying Drawings

Drawings may be created on paper or plastic film. Large drawings are duplicated by passing light through the material to a copy sheet below. Drawing materials must pass light so translucent materials are used.

**Drawing paper** is a high quality paper with plastic coating. **Vellum** is a naturally transparent paper which was used before plastic coatings came into use.

**Mylar film** is a very stable, tough plastic film which has a etched or coated drawing surface. Mylar is more expensive than paper but the stability and long term storage properties make it useful. Many hours of work and much information may be involved on a single page so the expense is justified.

**Cloth** drawings were used for many years. The material was a very high quality linen with starch coating. India ink was used to make the lines very dark. Many of these drawings are still in use.

Original drawings are carefully stored, often in fireproof vaults. Copies are created and used for production and other purposes. Blueprinting is an older process which required wet developers, washing and drying of the prints. **Diazo** is a newer process which creates dry prints right out of the machine. Diazo uses a print paper with a special coating. Once exposed to light the image is developed using hot ammonia gas.

Large format **digital** printers and copiers are replacing diazo process machines. Copies are more expensive but are sharper and longer lasting.

**Drawing Sheet Sizes** - USA Standard Inches

A = 8 1/2 x 11 or 9 x 12
B = 11 x 17 or 12 x 18
C = 17 x 22 or 18 x 24
D = 22 x 34 or 24 x 36
E = 34 wide by 4’, 5’, 6’, etc.
Measurements and Measuring Scales

Metric measurements are the world standard. The United States has been slow to fully adopt the metric system. Most new automobiles designs are done in metric with a few of the older english measurement parts included.

Architectural construction is mostly english measurement based. Construction materials like 2 x 4’s and 4 by 8 sheets of plywood do not have easy to work with metric equivalents. There is no great urgency to change.

Fractional inch measurements are used for some types of work and may be the measurement system used on older drawings. Reading fractional inch measurements may be difficult for new users. Calculating with fractional measurements is a very complex process. Try dividing 7 23/32 by 9?

Decimal inch measurements are easier to read on scales and much easier to calculate with. Metal decimal scales may have 100 divisions per inch. Plastic scales and scales printed in this book will show only the even hundredths.

Architectural measurements are composed of feet (base 12 with 12 inches to a foot) and inches (base 8,16,32 or 64 fractions to an inch). Calculating with feet, inches and fractions is also a very complex process.

Civil engineering units sometimes combine feet, inches and decimal inches which simplifies calculations.

Drawings for large items on paper are created using reduced scales. A 1/4 " = 1’ -0” architectural scale is shown. Each 1/4" is marked as a foot. Inches are shown to the left of "0". Large constructions may be placed on a small page using 1/4,1/8 or 1/16 scales.

Computer drawings are created full size (1=1) on the computer screen then reduced to fit the page at plot time.
IBM introduced the powerful and relatively inexpensive IBM-PC around 1983. AutoCAD introduced a usable drafting software program in 1984. AutoCAD emulated the paper drawing process using constructions and drawing processes similar to the way work was done on paper. Early computers used black and white monitors. It would be several years before the mouse became popular as a pointing device.

Industry quickly adopted computer drawing. The change from manual drafting to computer drafting was far faster than the change from typewriters to word processors in business. Computer drawings took about the same amount of time to create as manual drawings but the time savings in revising and updating drawings was a significant benefit. 2D drawings were created one line, one circle, etc. at a time just like on paper.

Computer networks provided quick access to stored files and fast exchange of information between designers.

Faster computers with better graphics and larger core memory have made possible the use of newer software which changes the drawing process. Three dimensional modeling allows the designer to work with solid images which are identical to the finished part. Once the 3D image is finished the process of creating the 2D working drawings requires only a few mouse clicks. 2D drawings which once took hours or days to complete now only take minutes to complete. Modeling mating parts reduces the chance of error when parts do not line up or fit properly.

Engineers and architects are able to transfer 3D mental images quickly and accurately to the computer screen. View controls allow the rotation of parts to better analyze the shape and critical elements of each design.

1984 IBM-PC 4.77 mhz processor, black and white monitor, 360k floppy drives, AutoCAD

3D Computer Solid Model

2D multiple view drawings are produced with only a few mouse clicks.
Computer drawings are plotted to standard size title block sheets. Early plotters drew lines using ink pens. This process produced accurate drawings but the pens skipped or ran out of ink at times. Newer plotters use ink-jet or laser printing processes which have fewer mechanical problems.

CAD/CAM is a process of taking 3D modeling data from the computer and converting it directly into machine tool control statements. It is possible to design a part and machine the part within a few minutes. Parts which used to take days to produce now take only minutes.

**Rapid Prototyping.**

One Stereolithography process builds parts in liquid polymer by fusing the polymer using ultraviolet light created by focused laser beams.
**Engineering Graphics Introduction**

**FILE NUMBER**

**GRADE**

**METRIC SCALE**
1 MILLIMETER DIVISIONS

**FRACTIONAL INCH SCALE**
1/32” DIVISIONS

**DECIMAL INCH SCALE**
.02” DIVISIONS

**MECHANICAL 1/2 SCALE**
INCHES AND FRACTIONS

**ARCHITECTURAL 1/2 SCALE**
FEET AND INCHES

**SCALES—1 SCALE COMPARISON**
Introduction Engineering Graphics

Used on plastic molding process

Inspection Template

Measure the distances shown

In millimeters.

Use a piece of paper as a gage.

Are in millimeters.

In Centimeters and the fine divisions

The centimeter scale has markings

On both scales are the same.

Of measure. Notice that the divisions

Millimeters are the most common units.

GRADE: ....................................
FILE NUMBER: ............................
DECIMAL INCH SCALE .02 IN MARKINGS

THE DECIMAL INCH SCALE OVERCOMES MOST OF THE READING AND COMPUTATIONAL PROBLEMS INHERENT IN THE FRACTIONAL INCH SCALE.

THIS SCALE IS STILL IN USE IN THE AUTOMOTIVE, AIRCRAFT AND ELECTRONICS INDUSTRIES.

USE THE EDGE OF A PIECE OF PAPER TO MEASURE THE DISTANCES.
RECORD THE ANSWERS BELOW:

L1 = ........... L2 = ...........
L3 = ........... L4 = ...........
L5 = ........... L6 = ...........
D1 = ........... D2 = ...........

L1  L2
L3  L6
D1 (DIAMETER)
Introduction to Engineering Graphics

A - 14

Fractions of an Inch - Full Scale

Fractions of an Inch Measurements are used in many applications. Reading and calculating using fractional measurements is more difficult than using decimal inch measurements.

Paper Sizes. To reduce large objects to fit small.

Fractions of an Inch and 1/4 scales are used.
THE ARCHITECTURAL SCALE MAY BE USED IN MECHANICAL, CIVIL, CHEMICAL AND OTHER ENGINEERING PROJECTS.

THIS SCALE IS THE MOST DIFFICULT TO USE WHEN CALCULATIONS ARE NEEDED.
CIVIL ENGINEERS’ SCALES

\[ 1’ = 50’ \]

\[ 1’ = 20’ \]

\[ 1’ = 10’ \]

\[ 1’ = 50’ \]

\[ 1’ = 20’ \]

\[ 1’ = 10’ \]

DISTANCES TO SMALLER DRAWING SIZES

THESE ARE USED TO REDUCE LARGE CIVIL ENGINEERING SCALES

GRADE FILE NUMBER