3D Model & Drawing Fundamentals (Graphic Communication)

December 2nd, 2011

Overview

- Mechanical Drafting/Drawings – Why it matters
- Drawing Fundamentals
  - Engineering & Technical Drawings
  - Handouts and Exercises
  - Working Drawings
  - Dimensioning & Tolerancing
- Introduction to Good Modeling Practices
- Hands On SolidWorks Project – Dec 3rd
  - Bring computer w/ SW and complete tutorials!

Mechanical Drafting/Drawings

- Why does it matter?
  - Computer Aided Design (CAD) does not replace mechanical 2D drawings
  - 2D drawings are still the primary graphical communication method
  - A thorough knowledge and understanding of 2D drawings will help you in any field, not just engineering
  - Standards exist to unify communication methods
    - Like proper grammar in languages, drawing standards ensure consistent understanding and interpretation

Mechanical Drafting/Drawings

- Why else does it matter?
  - Typically, 3D models are not the deliverable product
  - Most companies still rely on dimensioned, tolerenced, and complete 2D drawings for production
  - “Paperless” processes exist, but are a long way from being standardized
  - For many things, 3D models are just the simplified means to create 2D drawings
  - A solid understanding of CAD has little value without a stronger understanding of 2D drawings

Introduction

- The need for standardization
  - Engineering drawings are complicated and require a set of rules, terms, and symbols that everyone can understand and use – nothing is up for interpretation
- In the US, drawing standards are established by the American Society of Mechanical Engineers (ASME)
- The International Organization for Standardization (ISO) sets worldwide standards

Engineering Drawings

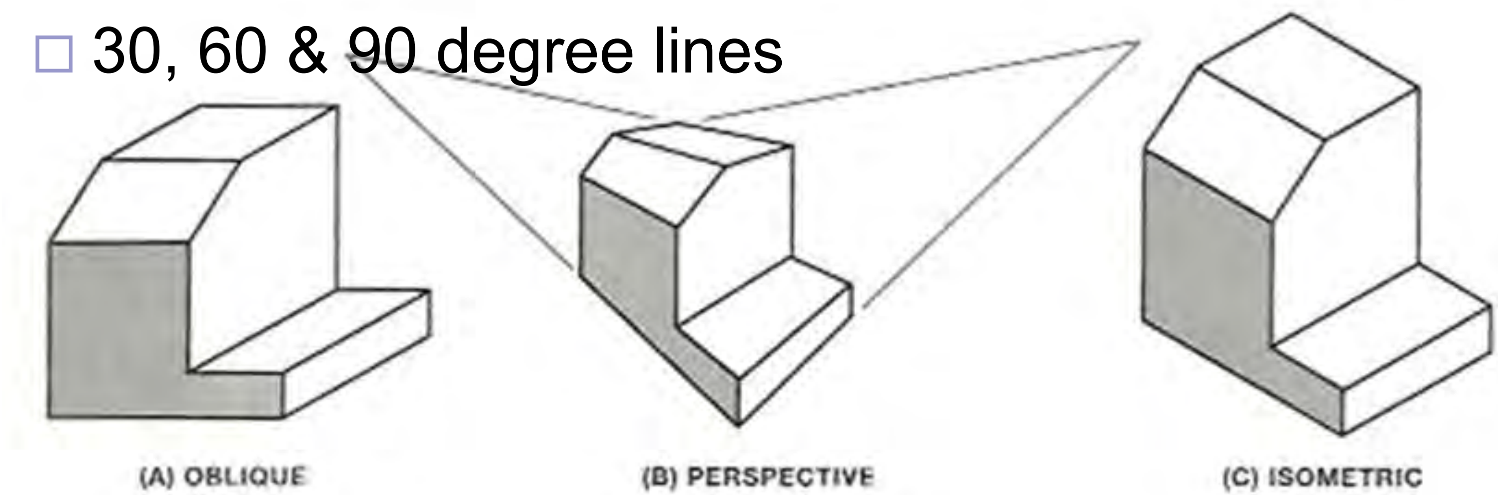
- Engineering or Technical Drawings
  - Furnish a description of the shape, size, features, and precision of physical objects
  - Other information needed for construction is given in a way that is easily recognizable to anyone familiar with engineering drawings
  - Primary drawings used when building FRC robots
    - We will focus on these types, but this knowledge is applicable across many fields
      - Architecture
      - Civil, Structural, Electrical, Aerospace, Mechanical Eng.
      - Graphic Design

Pictorial Drawings

- Similar to photographs
- Show objects as they would appear to the eye of the observer
- Not often used for technical designs, because interior features and complicated detail are easier to understand and dimension on orthographic drawings
- In industry, must clearly show the exact shape of objects and cannot be accomplished in just one pictorial view

Pictorial Drawings

- Oblique
  - Front face flat, 45 degree sides
- Perspective
  - Vanishing Points
- Isometric
  - 30, 60 & 90 degree lines



Orthographic Projection

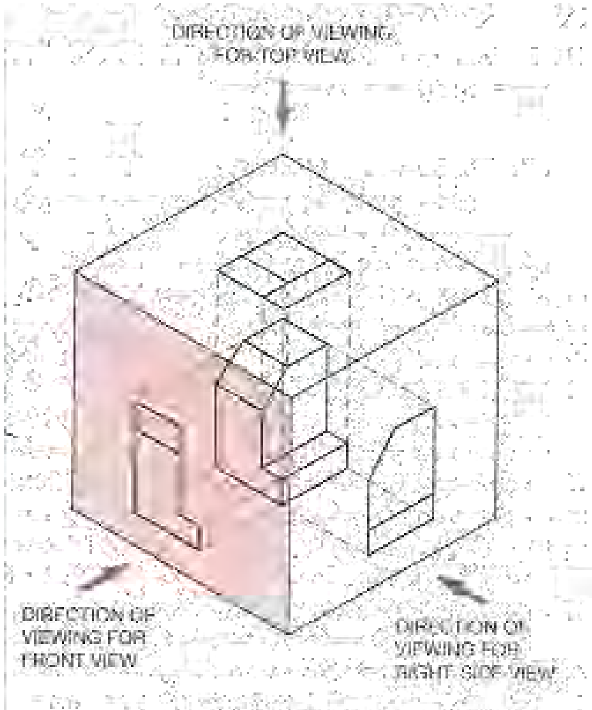
- Method to convey information about all hidden and visible features of a part
- Typically referred to as front view, top view, and right side view, etc.
- Systematically arranged on the drawing sheet and projected from one another
- Essential to understanding and visualizing an object
- Principles can be applied in four angles or systems (only two commonly used – first and third angle)

Third Angle Projection

- Used almost exclusively on all mechanical drawings in North America
- Three views are usually sufficient to describe an object in it's entirety
  - Top, Front, Right Side

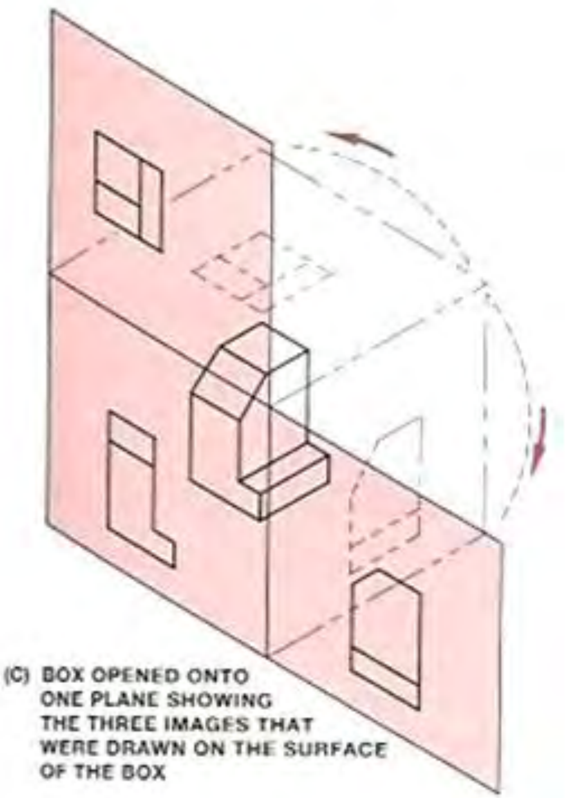
Third Angle Projection

- Glass Box



(B) OBJECT ENCLOSED IN A GLASS BOX AND IMAGES OF OBJECT DRAWN ON SURFACES OF BOX

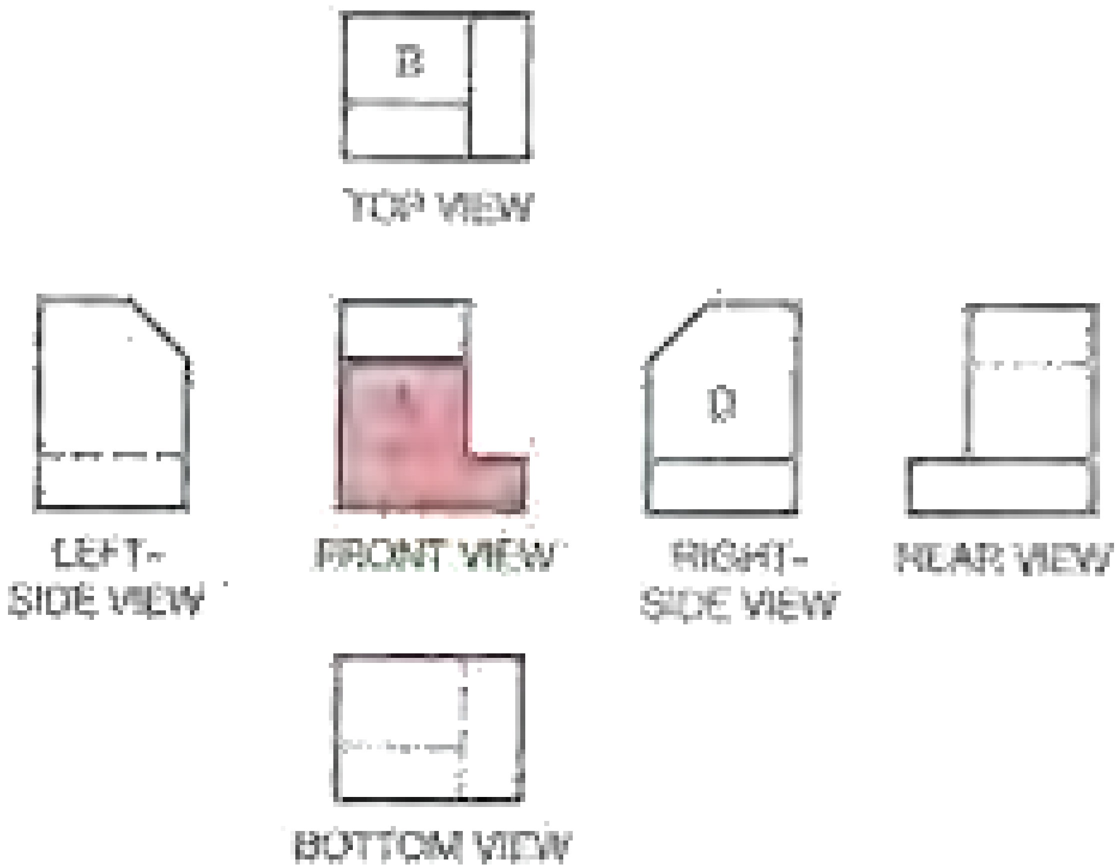
- Open Box


(C) BOX OPENED ONTO ONE PLANE SHOWING THE THREE IMAGES THAT WERE DRAWN ON THE SURFACE OF THE BOX

Third Angle Projection

- Six Principle Views
  - Front View-placed center
  - Top View-placed above
  - Bottom View-placed below
  - Left View-placed left
  - Right View-placed right
  - Back View (rear)-placed at extreme left or right

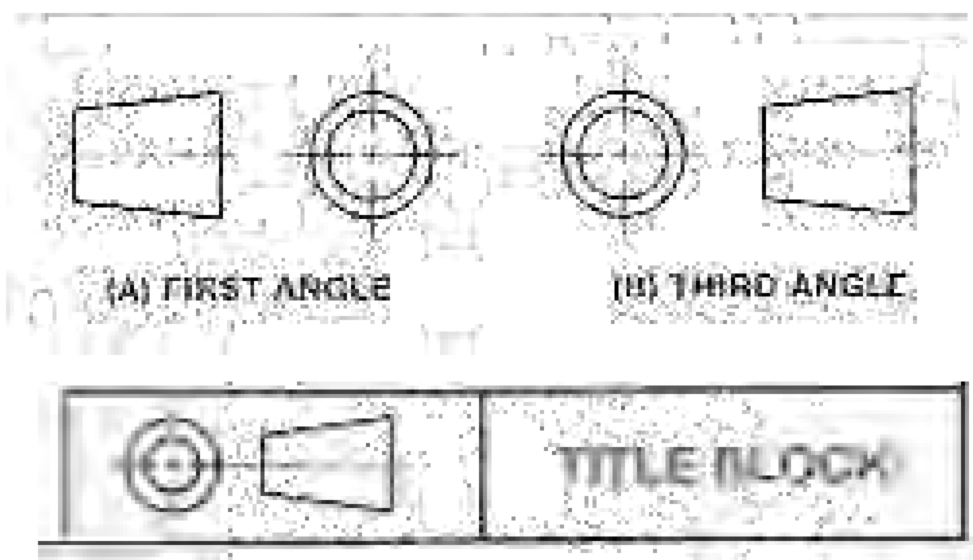
Six Principle Views



(D) THE SIX PRINCIPAL VIEWS

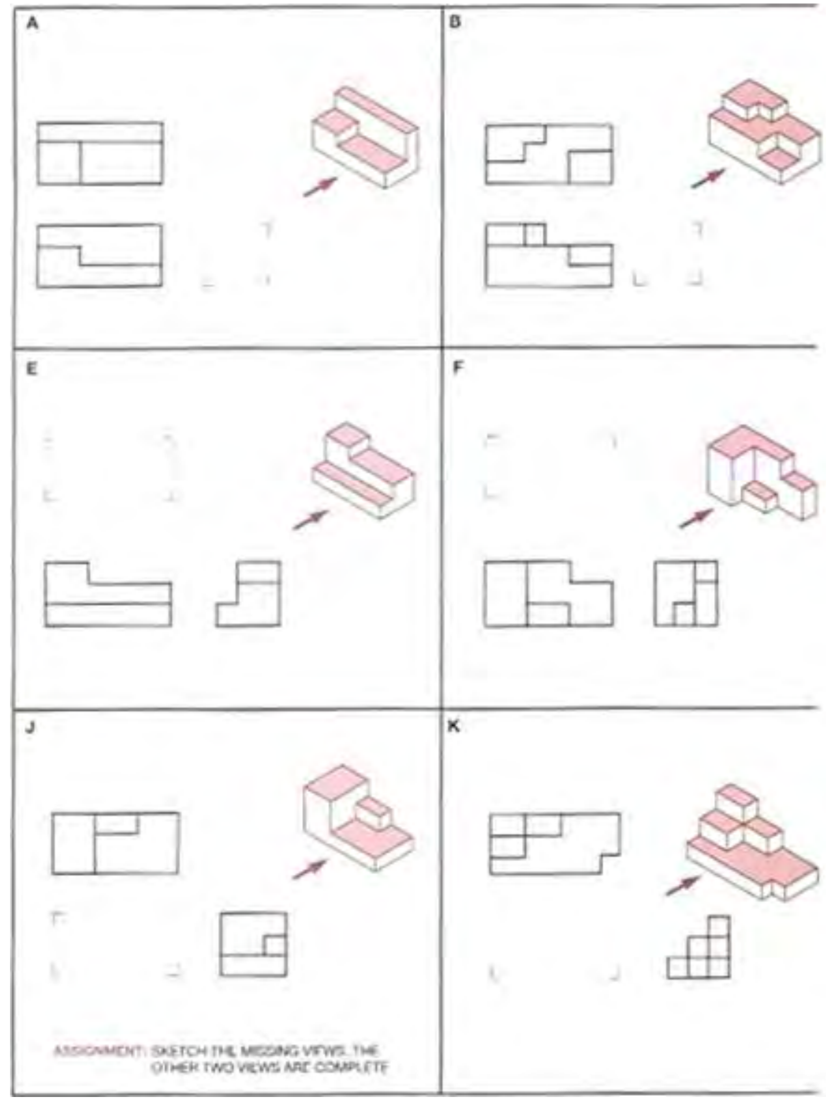
ISO Projection Symbol

- Two systems of orthographic projection exist
  - Must clarify which is being used
- ISO symbol located adjacent to title block on drawing



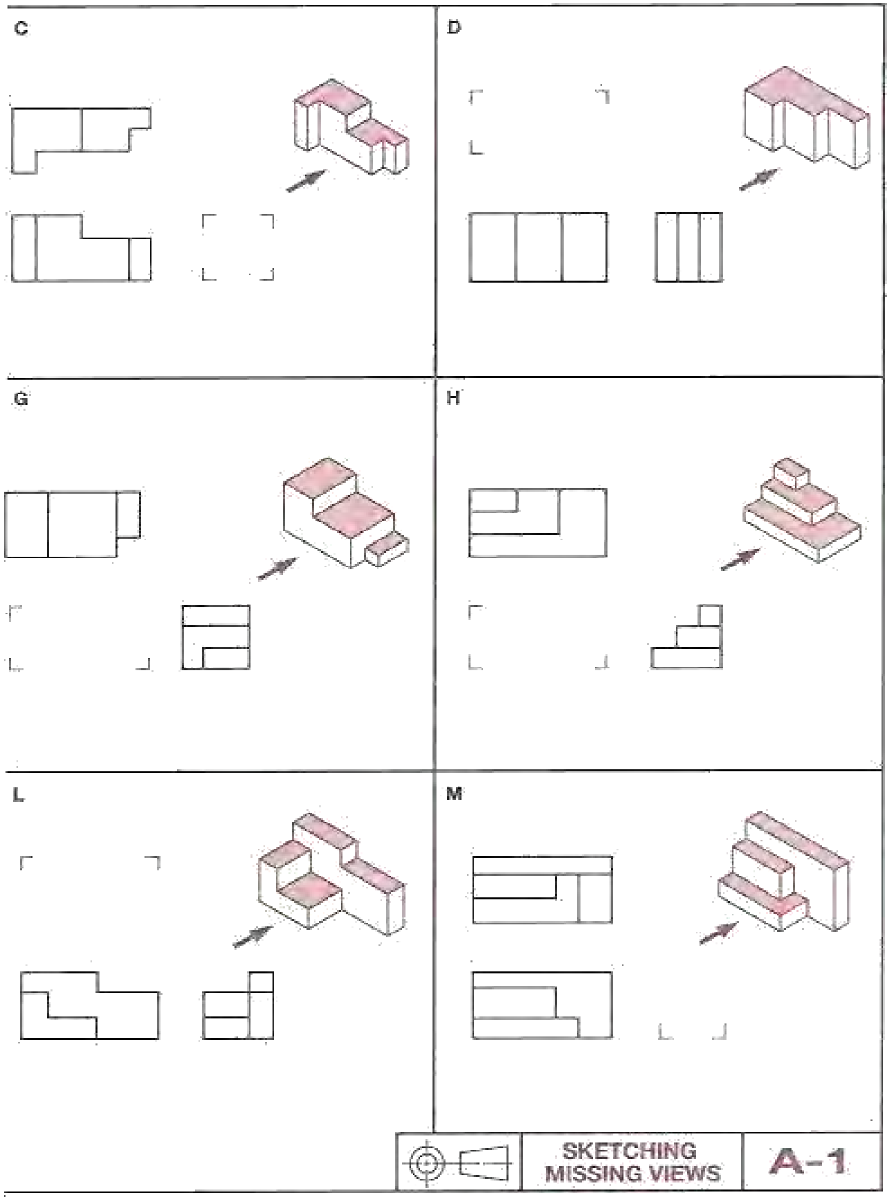
Handout 1

- Sketch the missing views (the other two views are complete)

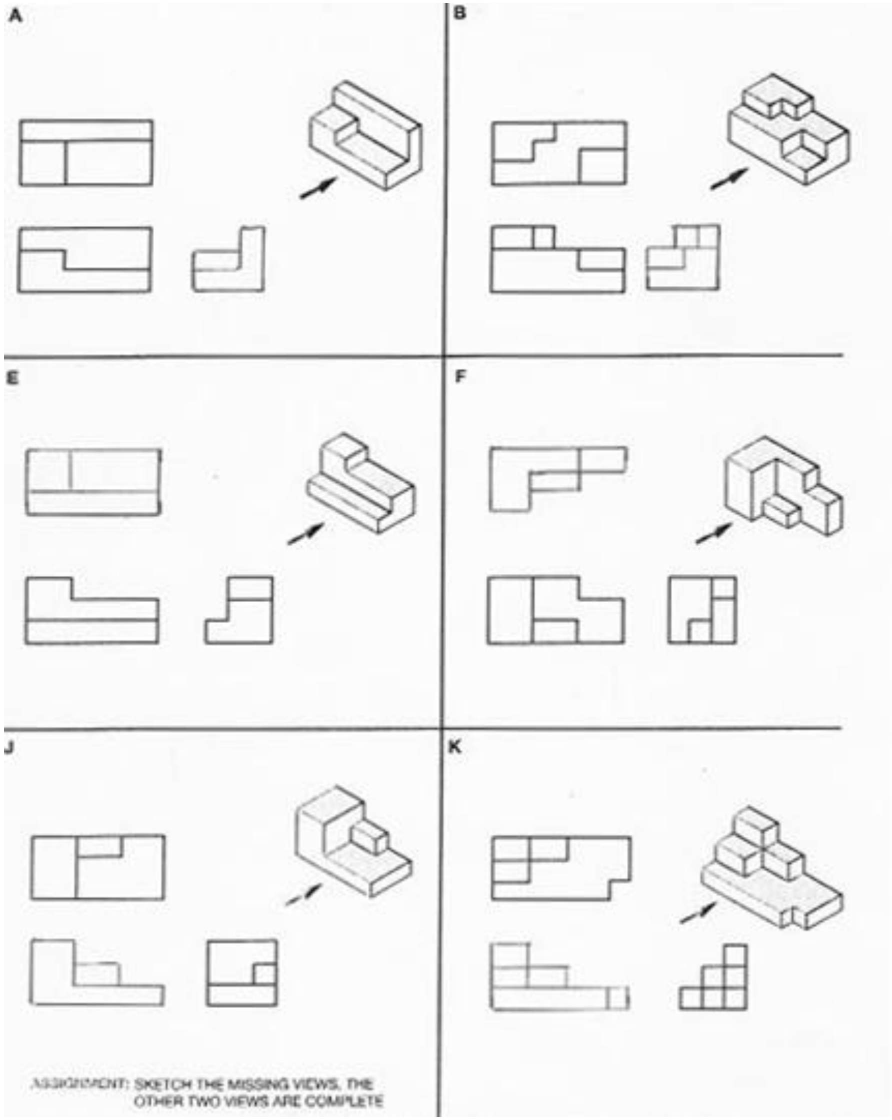


Handout 2

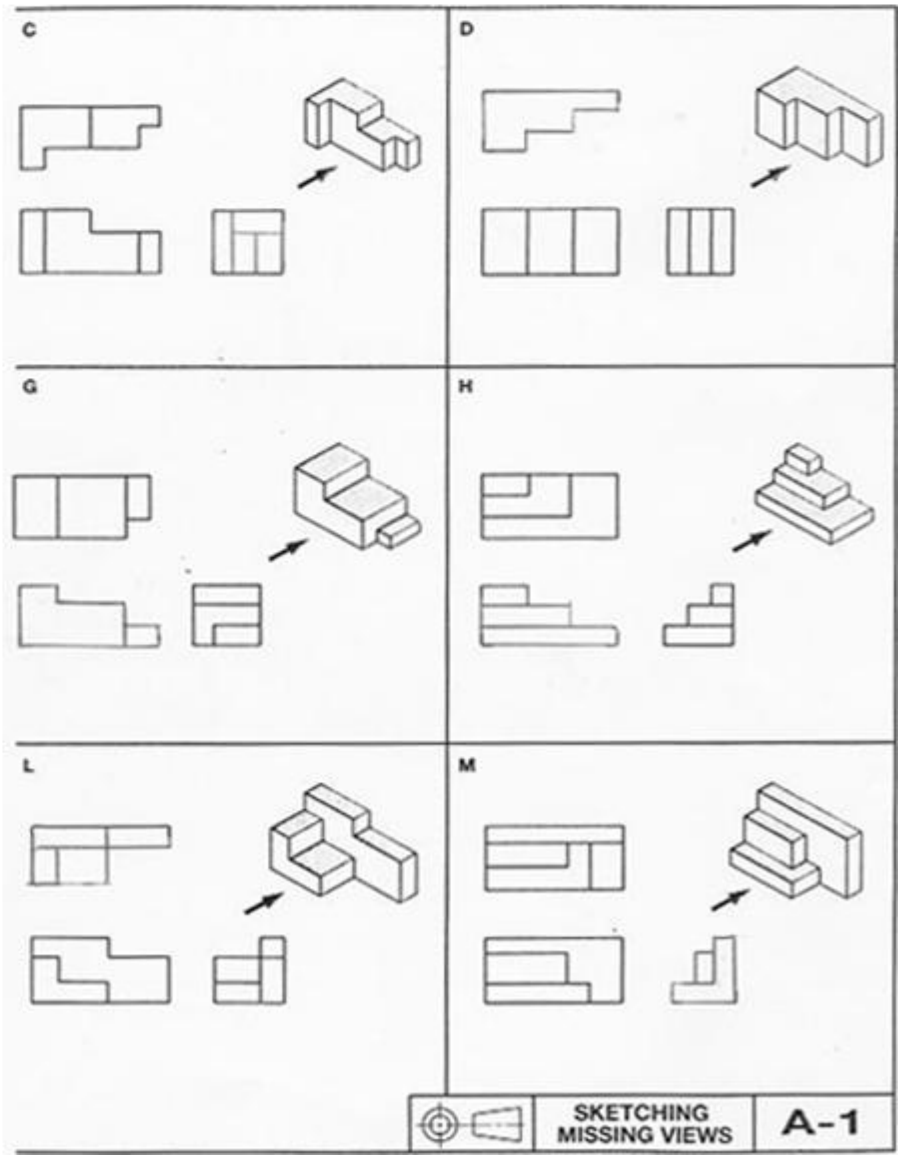
- Sketch the missing views (the other two views are complete)



Handout 1 Solutions

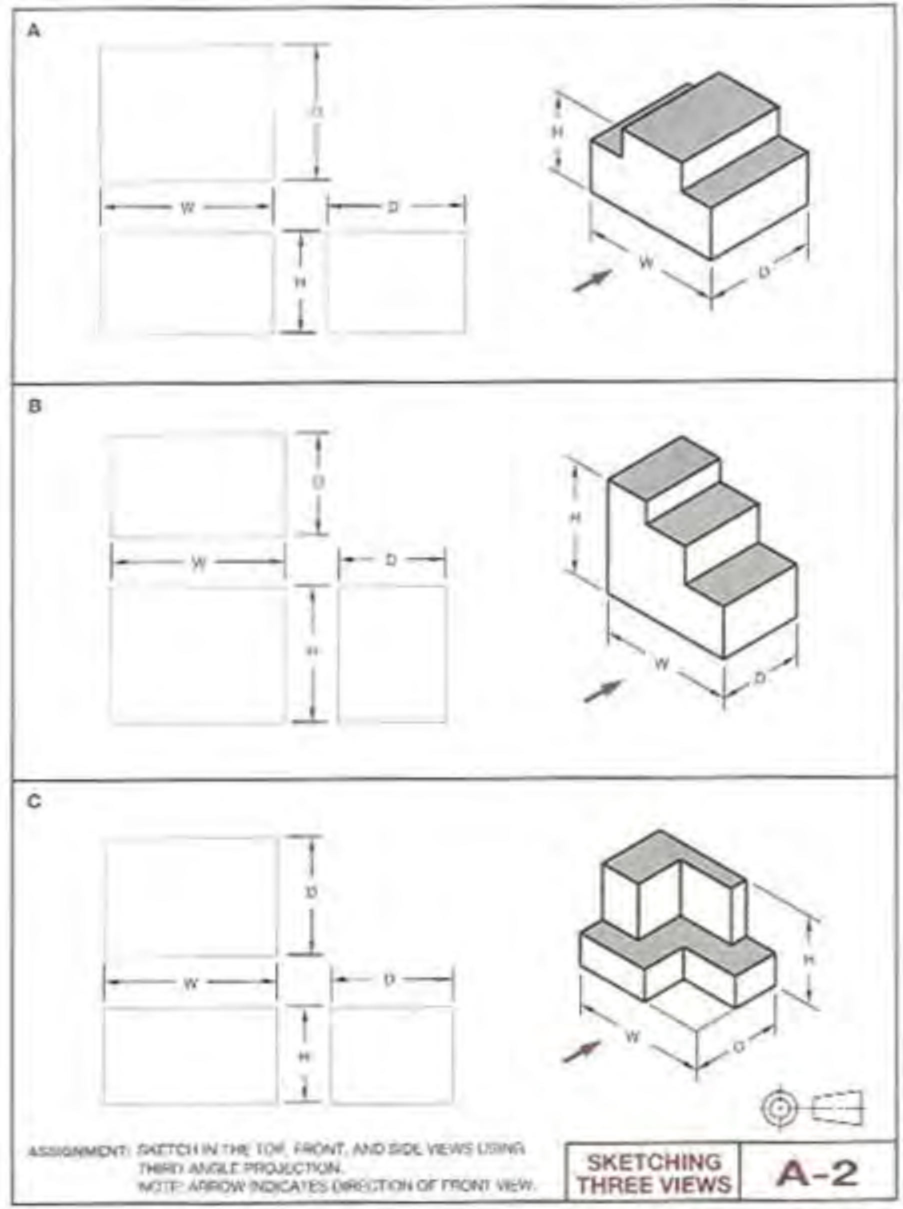


Handout 2 Solutions

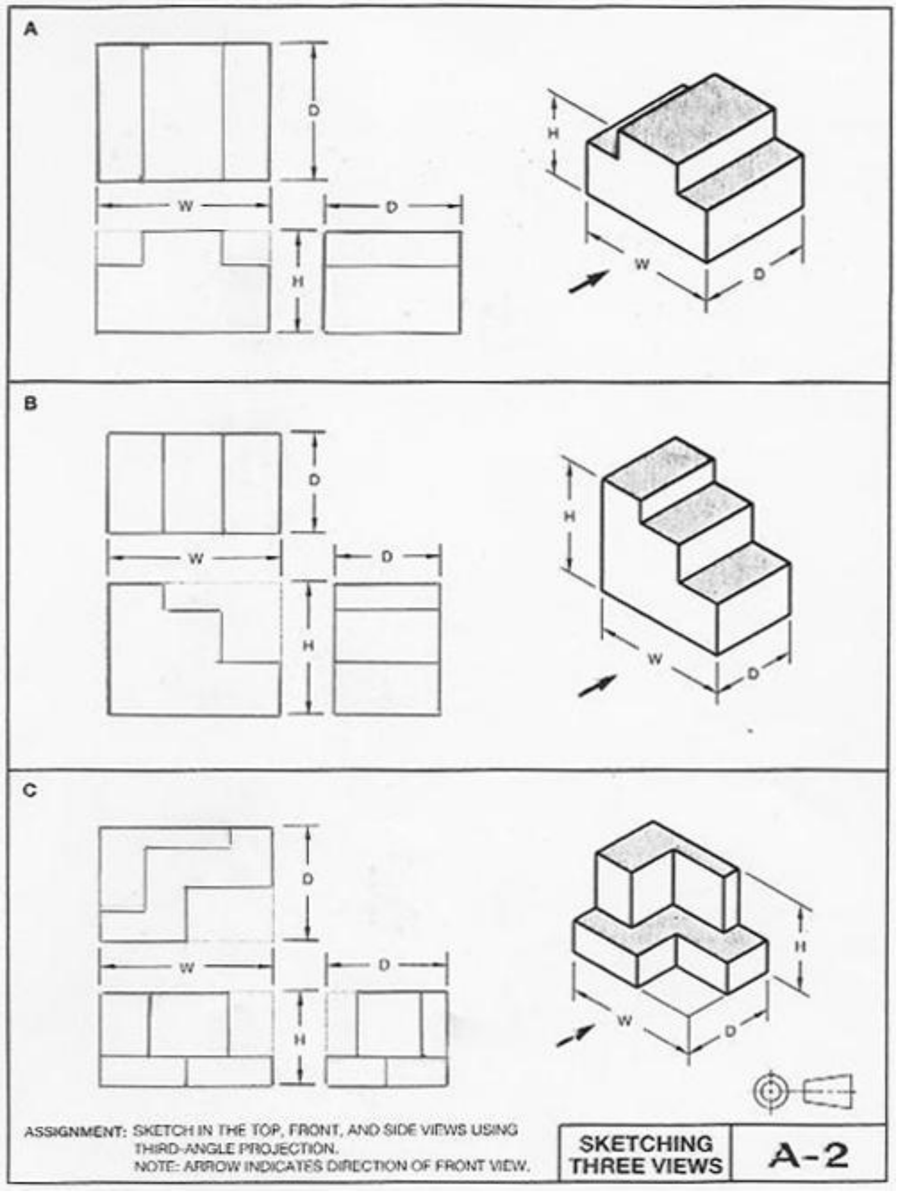


Handout 3

- Sketch in the top, front, and side views using third angle projection

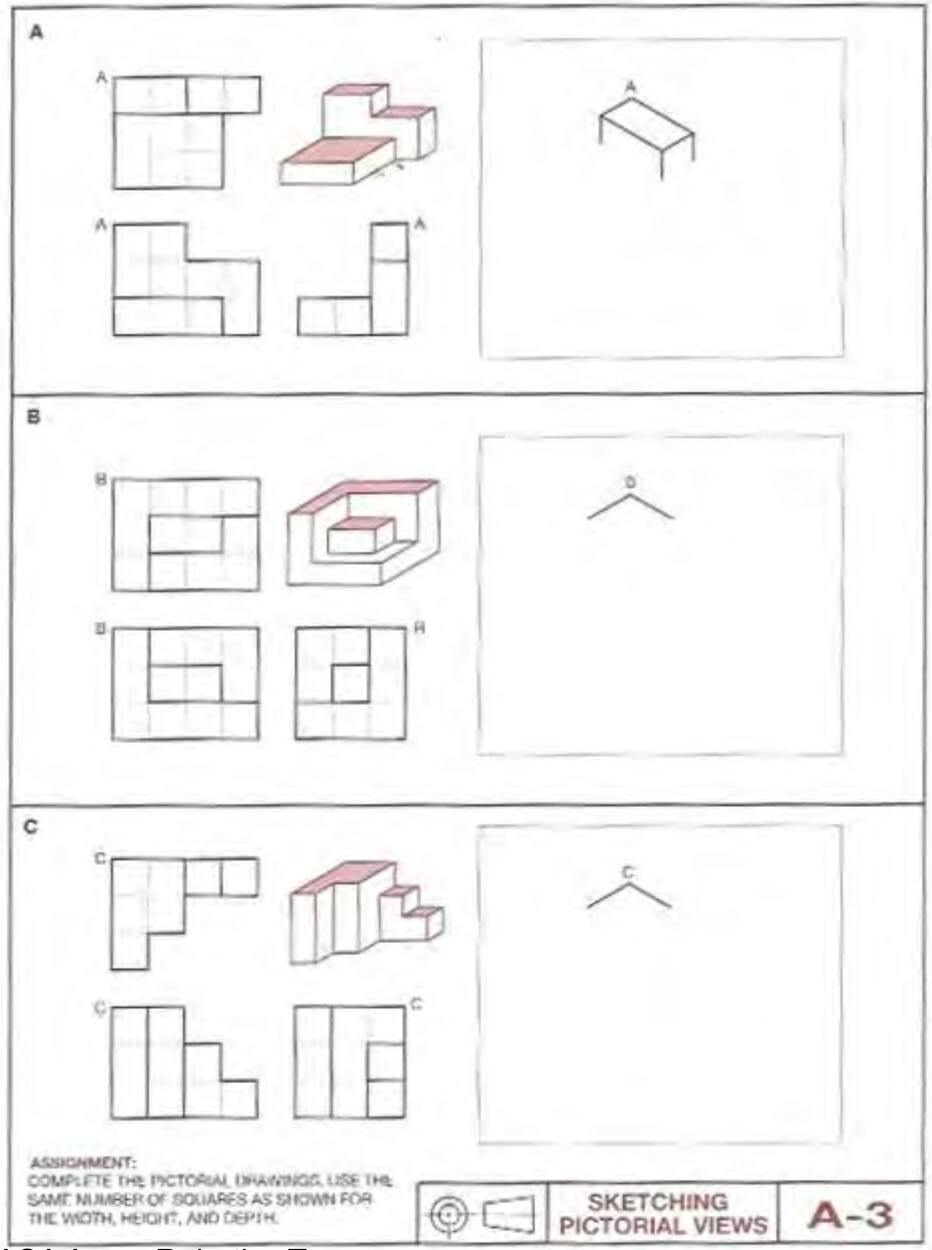


Handout 3 Solutions

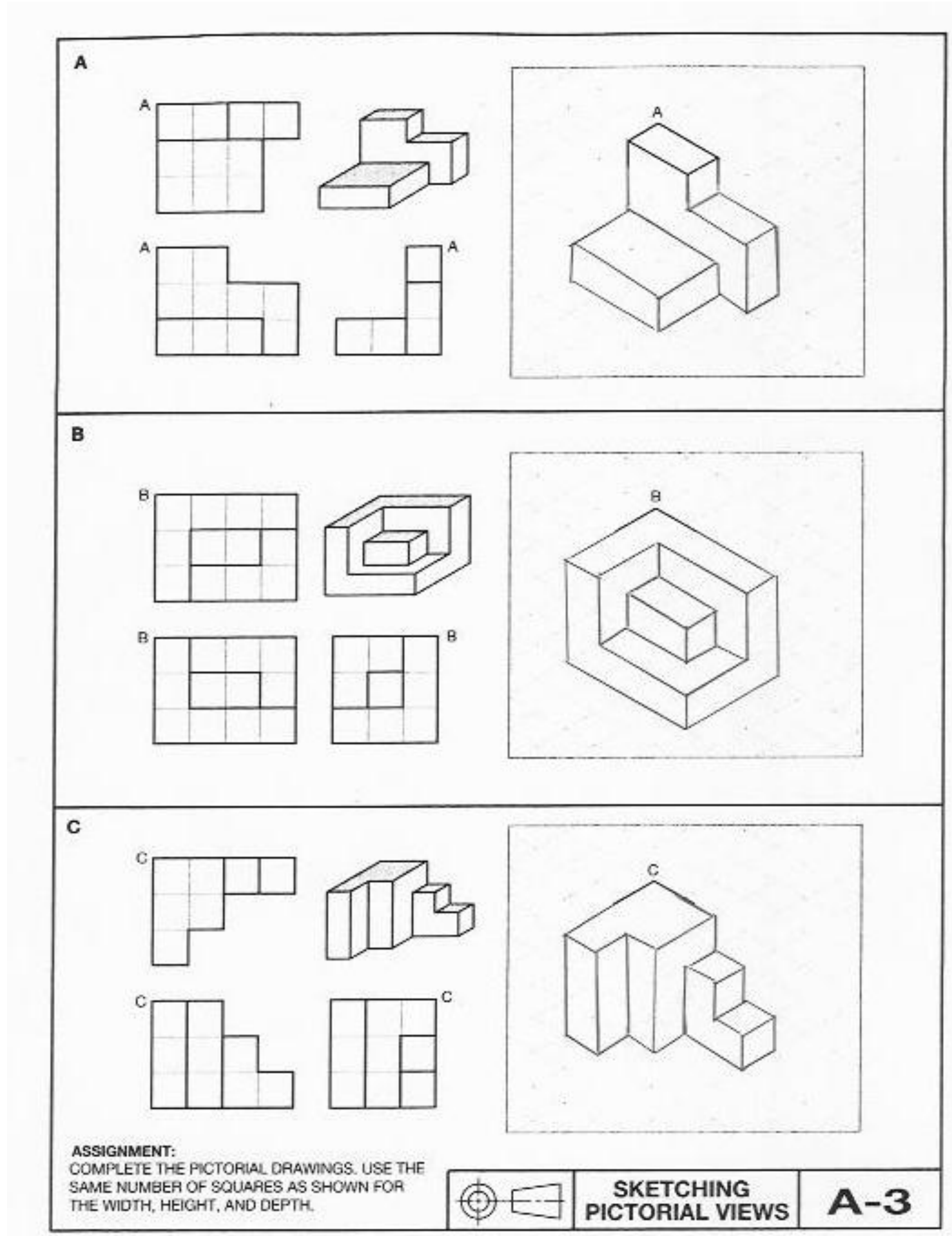


Handout 4

- Complete the pictorial drawings



Handout 4 Solutions



Working Drawings

- Assembly or detail drawing
- Contain complete information for assembly or construction of a product or object
- Classified under three headings
  - Shape
  - Dimensioning
  - Specifications

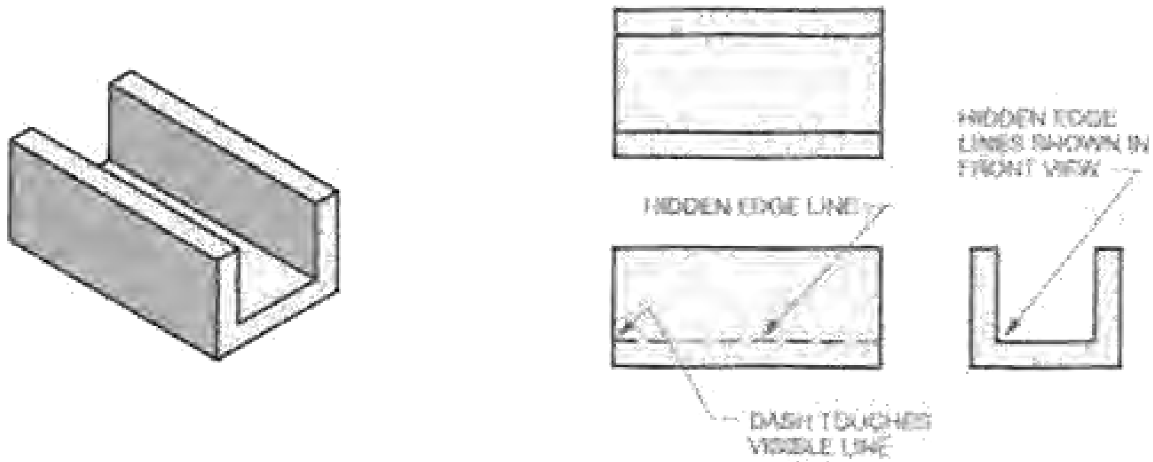
Line Types

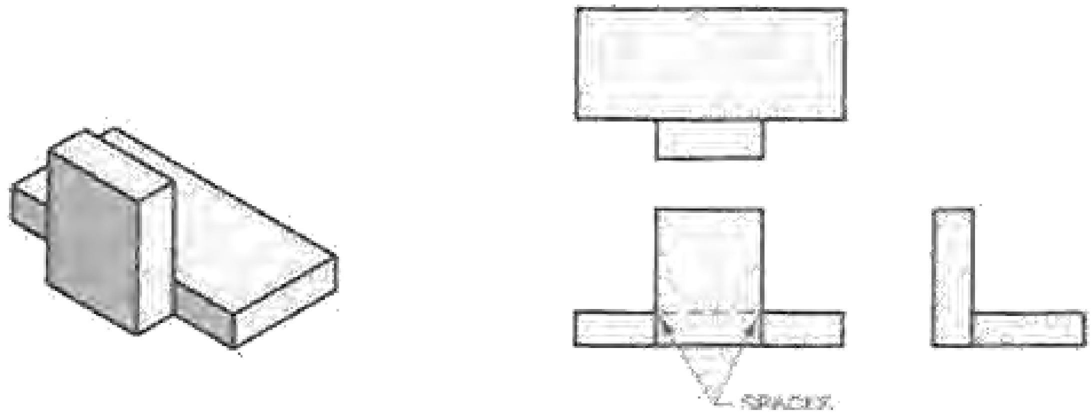
- Visible lines
  - Thick solid line used to indicate edges and corners of an object
  - Should stand out clearly in contrast to other lines
  - Makes general shape of object apparent to the eye

Line Types

- Hidden Lines
  - Series of short dashes
  - Vary slightly depending on size of drawing
  - Illustrate features such as lines and holes that cannot be seen from the outside of the piece
  - Usually required to show true shape of object
  - May be omitted to preserve clarity

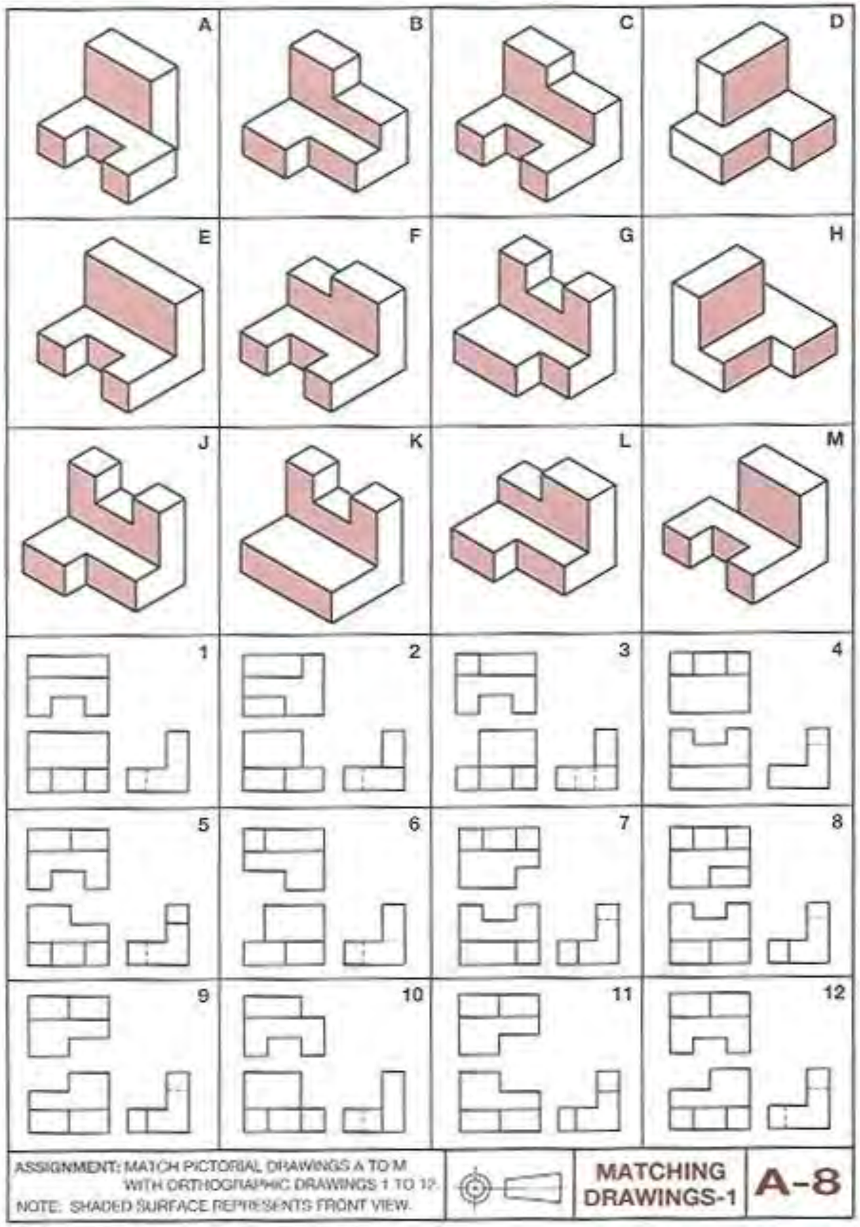
Hidden Lines



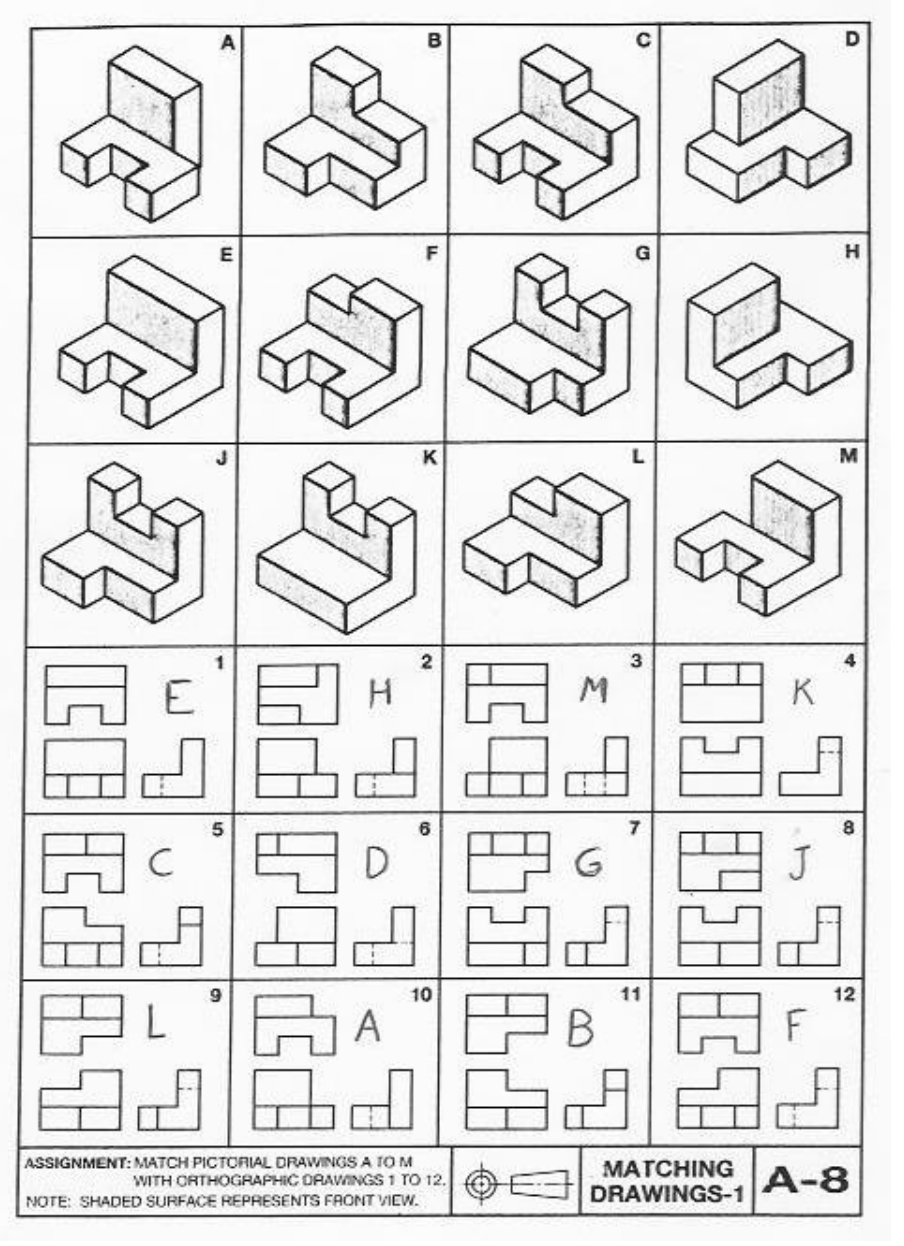


Handout 5

- Match drawings to pictorial view

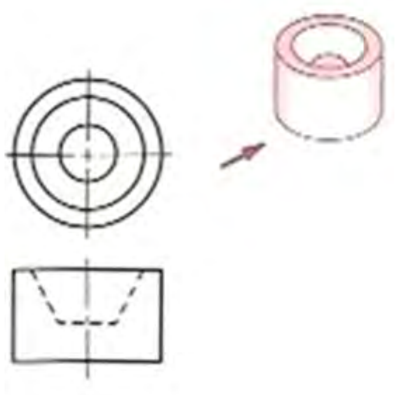


Handout 5 Solutions

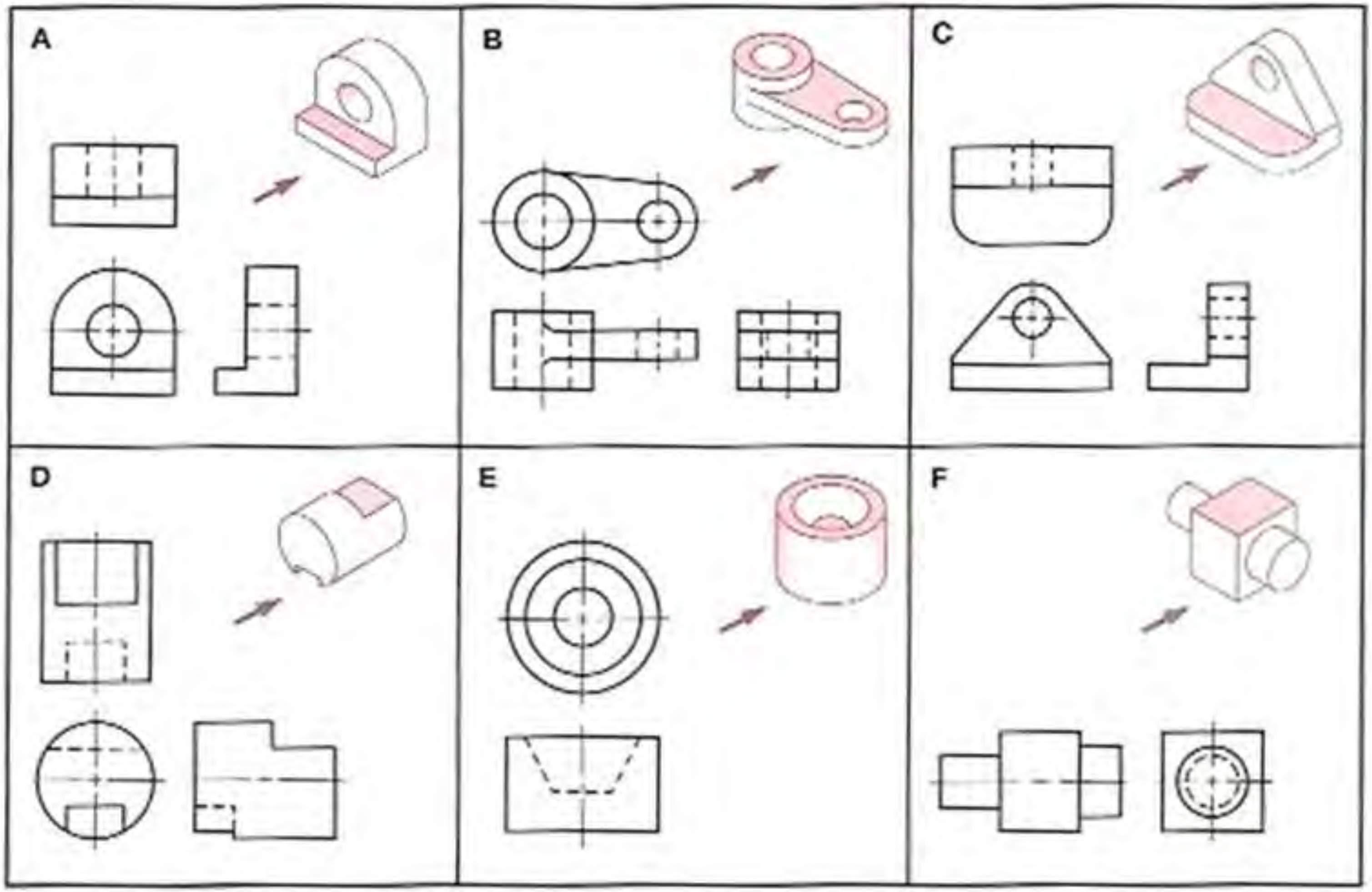


Circular Features

- Appear circular in only one view
- No line is used to indicate where a curved surface meets a flat surface
- Hidden circles represented by hidden and center lines
- Often only two views required for circular/cylindrical parts



Circular Features



Drawing Views and Sheets

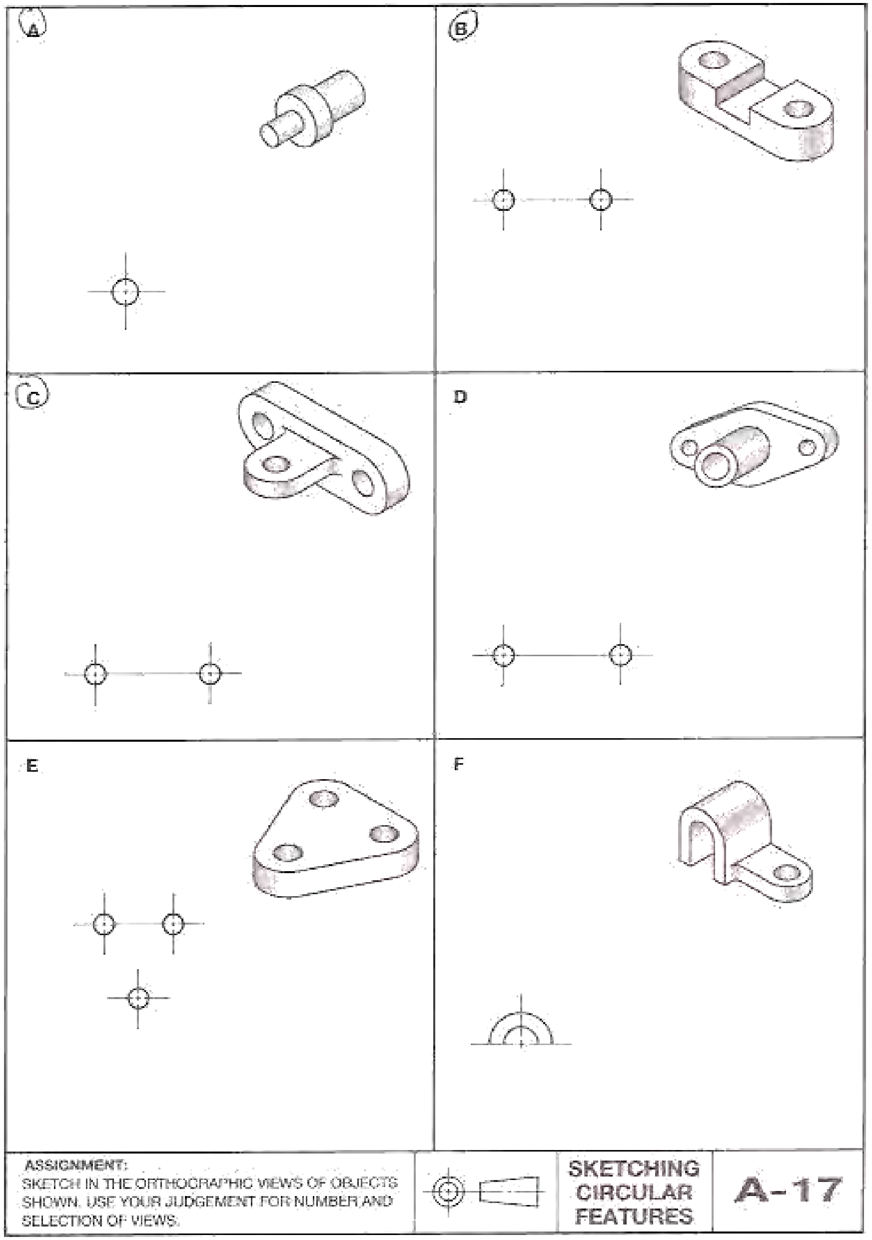
- How many views/sheets are required?
  - As many as necessary to clearly show all features, sections, details and dimensions to fully explain the part and the tolerences required to make it
  - Some “simple” parts can take many sheets with dozens of views to ensure complete definition

Line Types

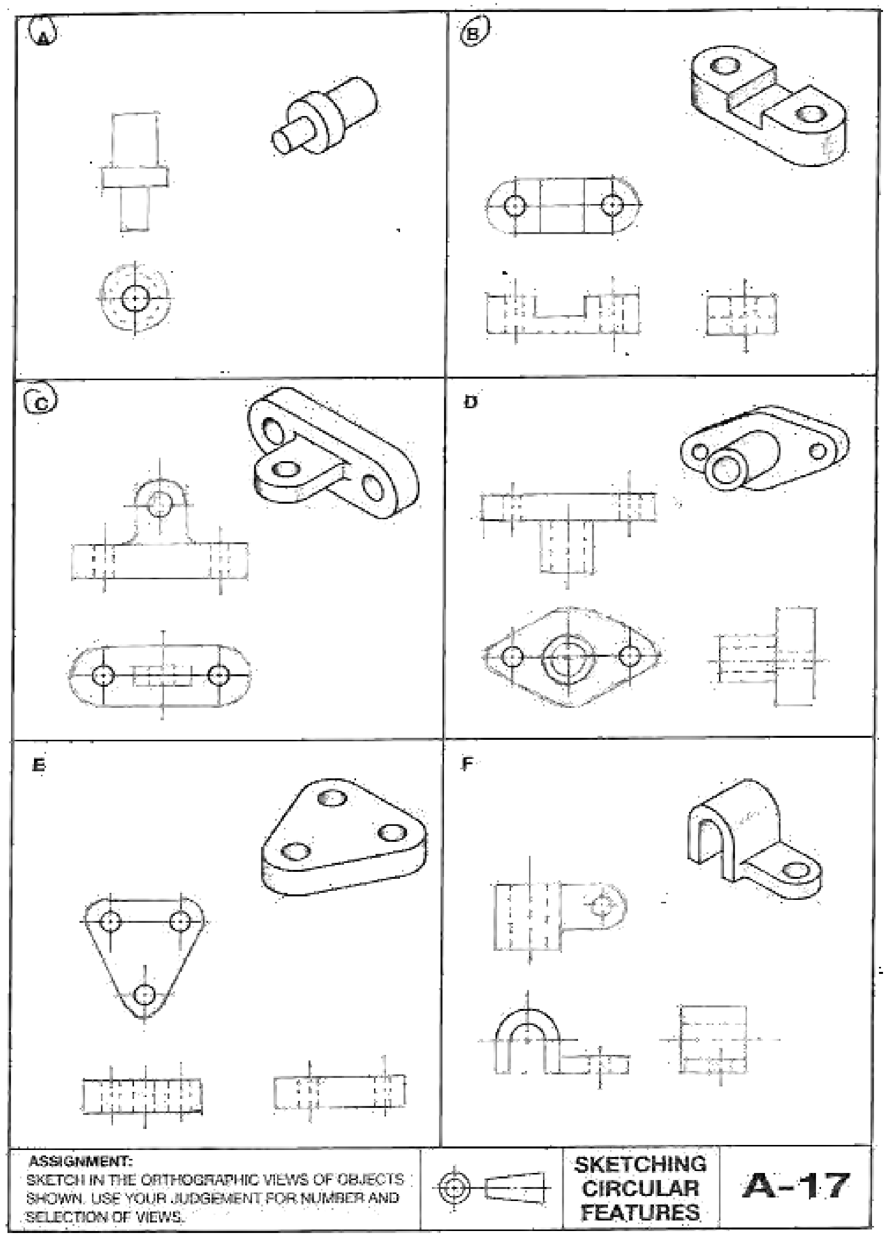
- Center Lines
  - Drawn as a thin broken line of alternating long and short dashes
  - Used to indicate center points, axes of cylindrical parts, and axes of symmetry

Handout 6

- Sketch the orthographic views
- Use your judgment for number and selection of views



Handout 6 Solutions

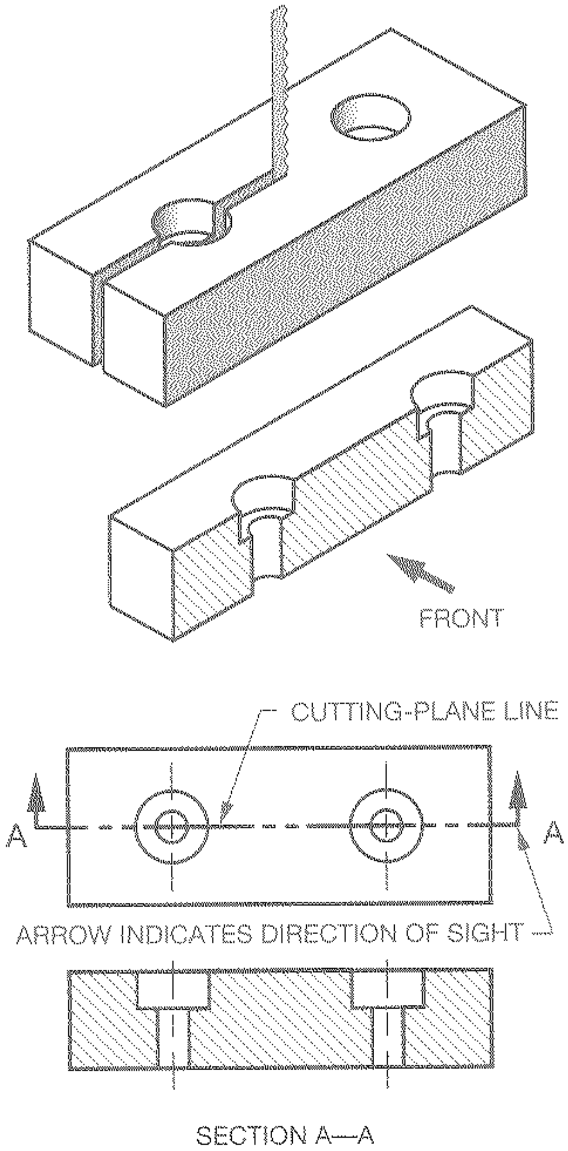


Sectional Views

- Used to show interior detail too complicated to show with outside and hidden views
- Obtained by assuming nearest part of object has been cut and broken away through an imaginary cutting plane

Section Views

- Theory



Section Views - Line Types

- Cutting Plane
  - Indicates where the imaginary cutting takes place
  - The ends of the cutting plane line are bent at ninety degrees and are terminated in arrowheads to indicate the direction of sight for viewing
  - View placed opposite to arrow direction
  - No cutting planes may exist on section view
  - Subtitles used to specify section view

Section Views - Line Types

- Section Lining
  - Indicate surface that has been cut and makes it stand out clearly
  - Thin parallel lines placed at 45 degrees to principal edges or axis of the part
  - Uniform spacing

Section Views

- Section Types
  - Full Sections
    - Cutting plane extends entirely through the object in a straight line
  - Half Sections
    - A symmetrical object may be drawn as a half section showing one half up to the center line of the part
  - Offset Sections
    - Allows sectioning of features that are not in a straight line

Section Views

- Section Types

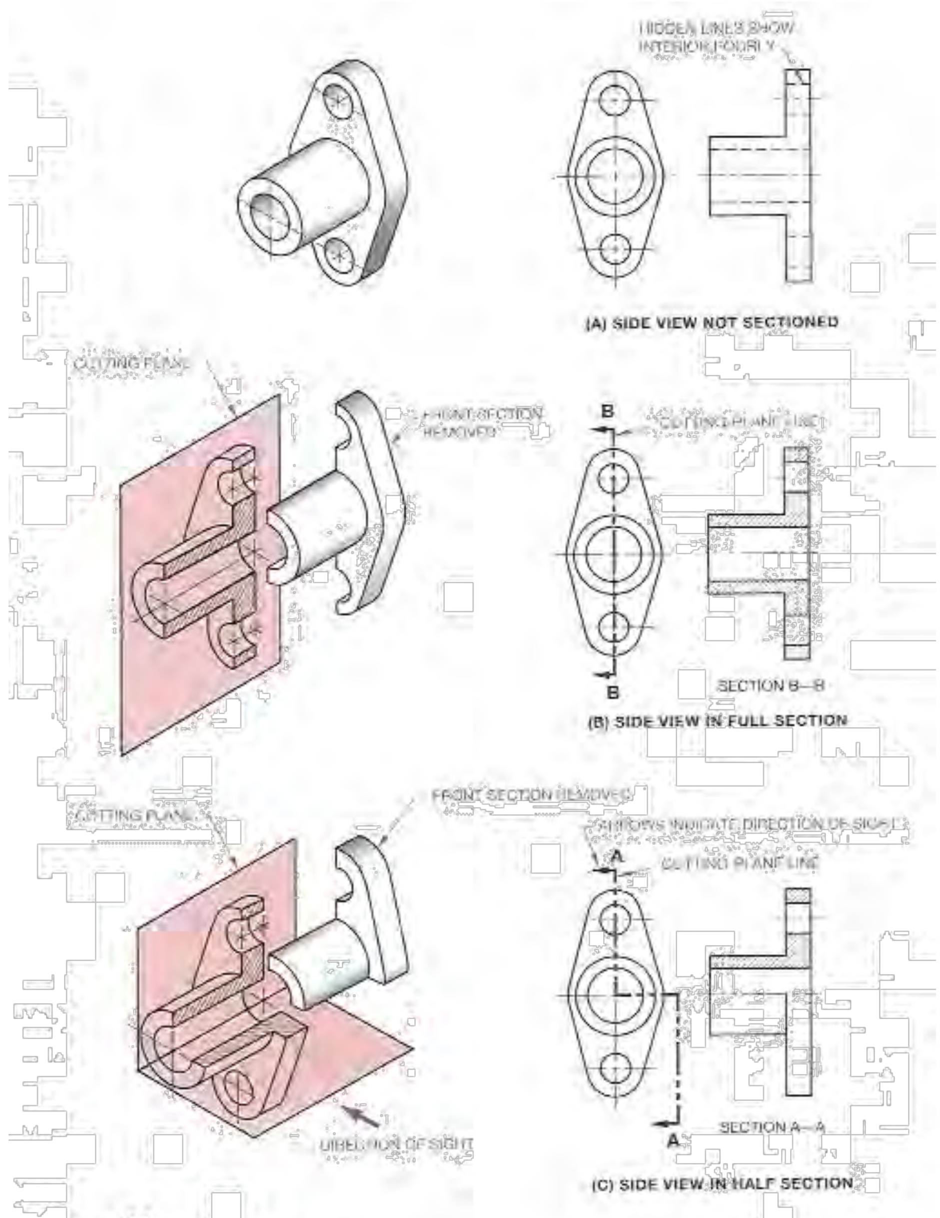


FIGURE 8–5 ■ Full and half sections

Dimensioning

- Indicated by
  - Extension lines
  - Dimension lines
  - Leaders
  - Arrowheads
  - Figures
  - Notes
  - Symbols

Dimensioning

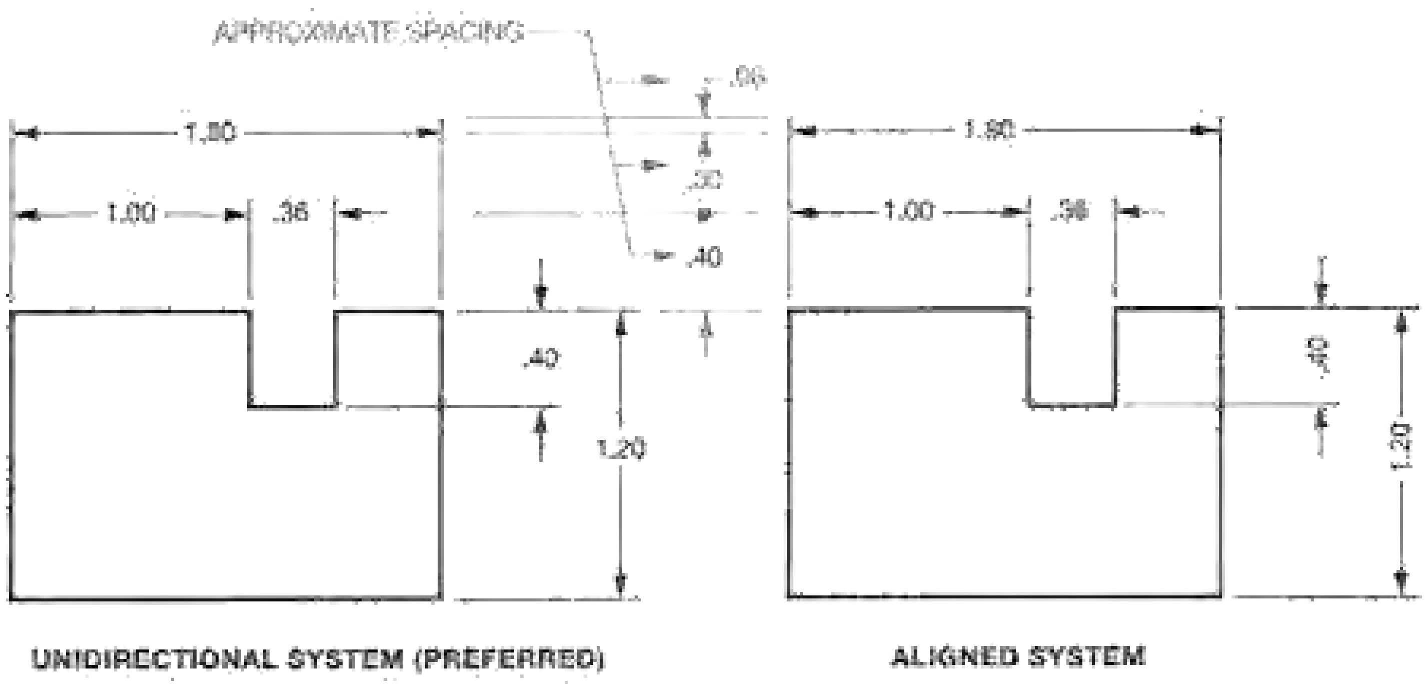
- Define geometrical characteristics:
  - Distances
  - Diameters
  - Angles
  - Locations
- Lines used are thin in contrast to the outline of the object
- Must be clear and concise, permitting only one interpretation (No redundant dimensions)

Dimensioning

- Placement of dimensions
  - Unidirectional
    - Read from the bottom only-all nomenclature is horizontal
  - Aligned
    - Outdated and no longer used
    - Read from the bottom and right side

Dimensioning

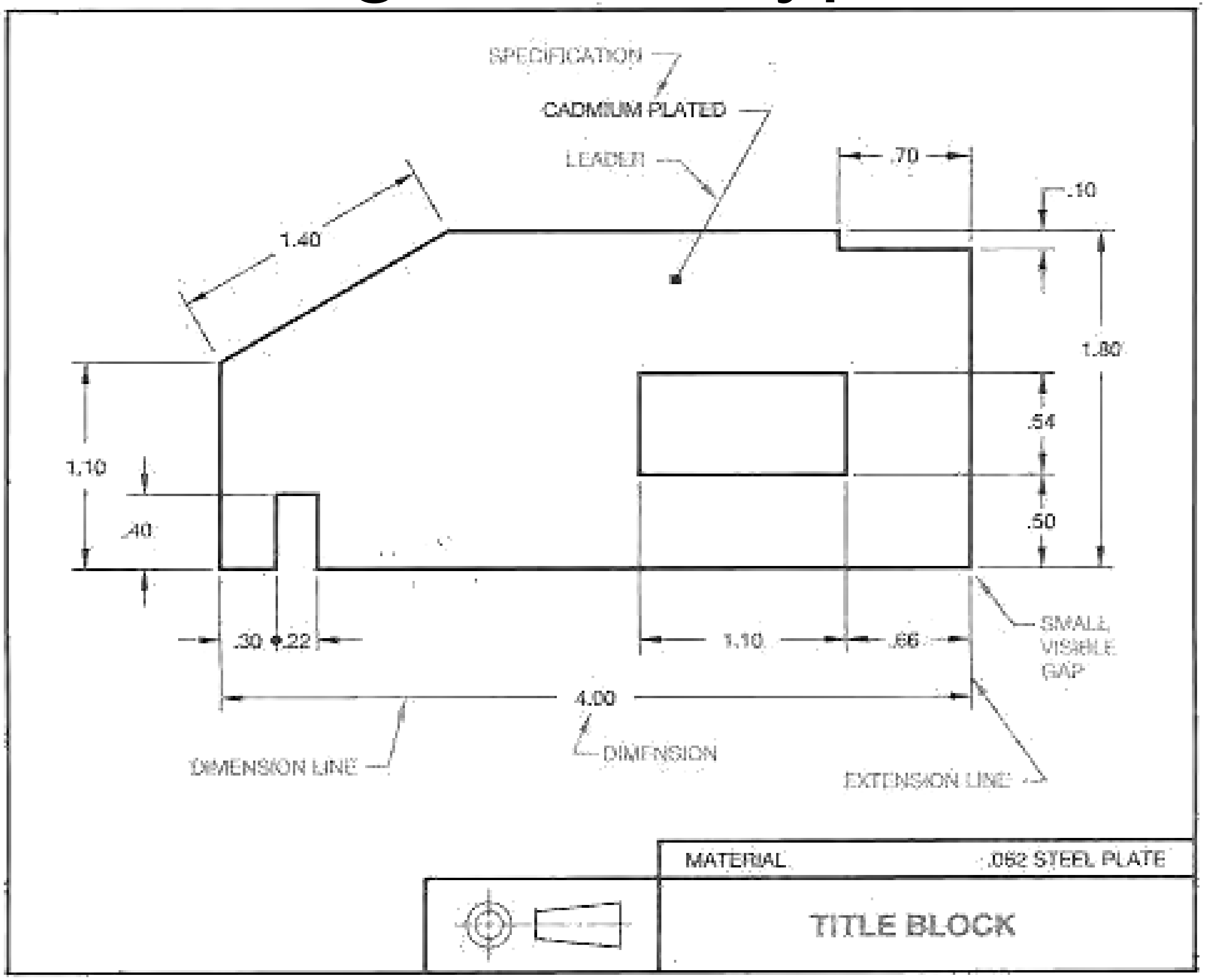
- Unidirectional vs. Aligned Systems



Dimensioning – Line Types

- Dimension Lines
  - Denote particular sections of the object
  - Should be drawn parallel to the section they define
  - Terminate in arrowheads
- Extension Lines
  - Denote points or surfaces between which a dimension applies
  - Extend from object lines and are perpendicular to dimension lines

Dimensioning – Line Types

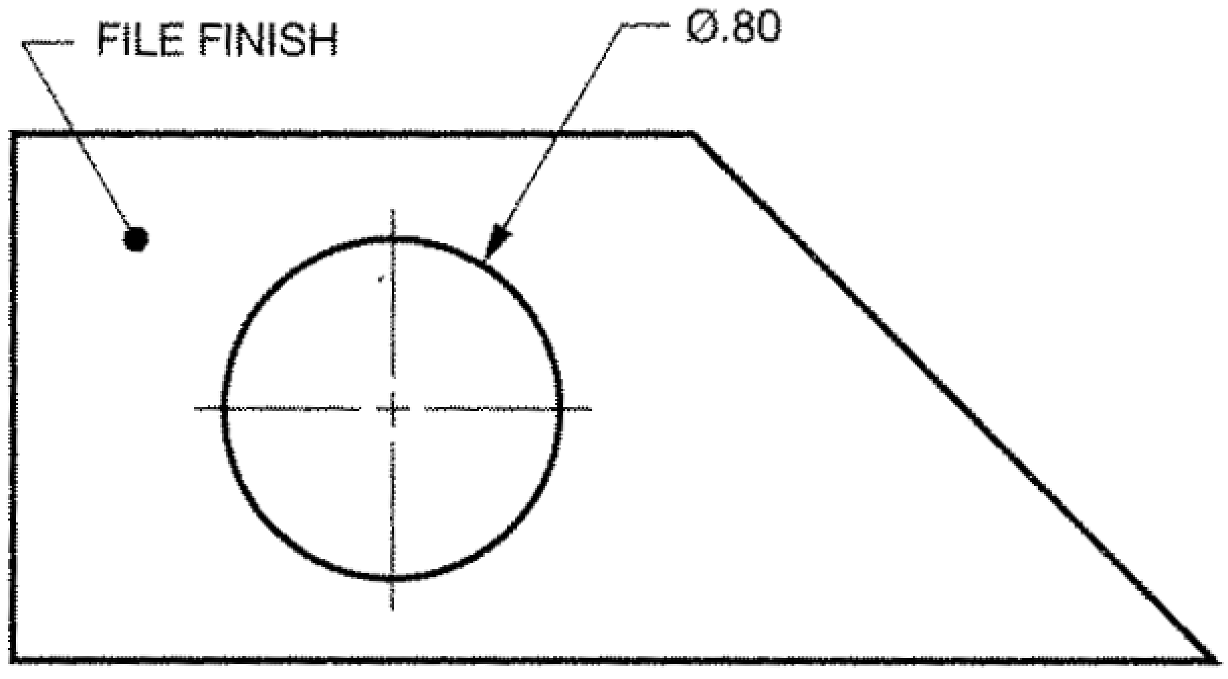


Dimensioning – Line Type

- Leaders
  - Used to direct dimensions or notes to the surfaces or points to which they apply
  - Consists of a line with or without short horizontal bars adjacent to the note or dimension, and an inclined portion that terminates with an arrowhead touching a line, point, or surface to which it applies

Dimensioning-Line Type

- Picture of Leaders



Dimensioning - Units of Measure

- Inch units of measurement
  - Decimal inch system (US customary)
    - Ex: 14.375
    - Take note of number of decimal places
  - Fractional inch system
    - Ex: 14 3/8
  - Feet and inches system
    - Ex: 1’-2 3/8

Basic Rules for Dimensioning

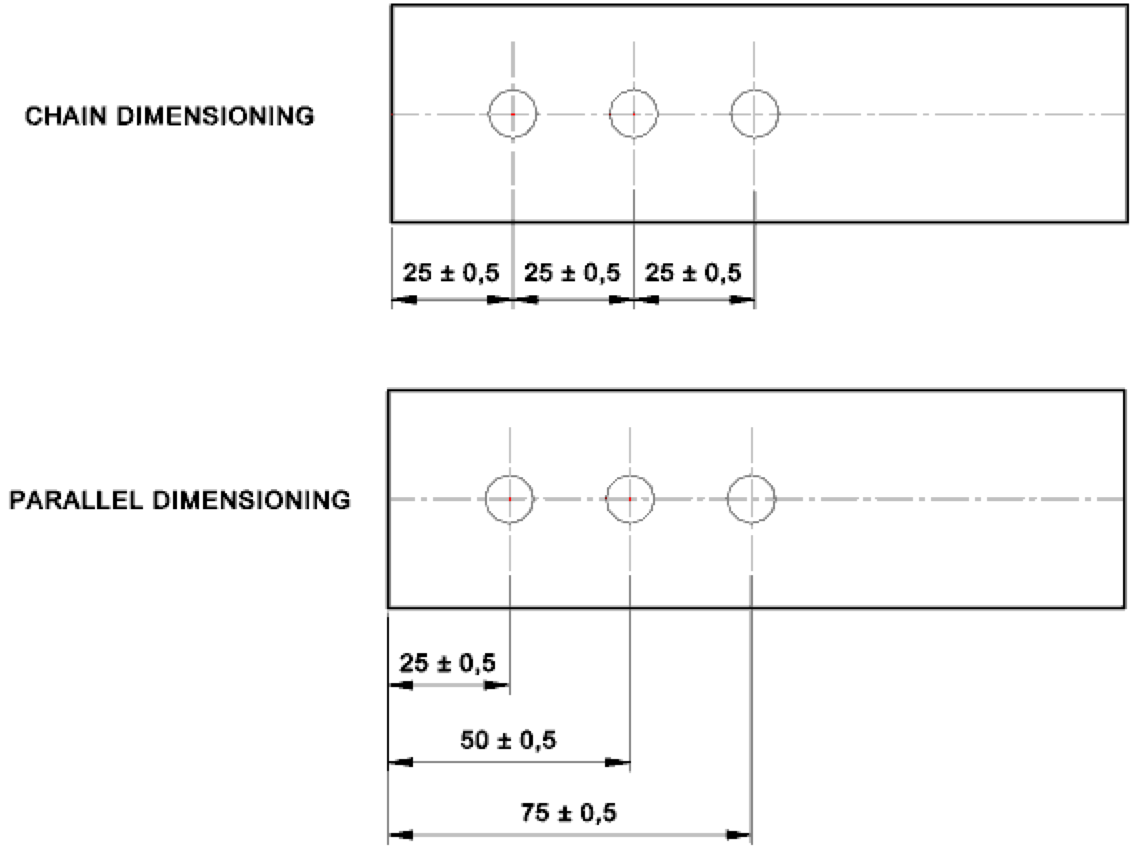
- Place the dimension line for the shortest width, height, and depth nearest the outline of the object
  - Parallel dimension lines are placed in order of their size, making the longest dimension line the outermost line
- Place dimensions near the view that best shows the shape or contour of the object
- On large drawings dimensions can be placed on the view for clarity

Basic Rules of Dimensioning

- Chain vs. Baseline (Parallel) dimensioning
  - Chain dimensions are referenced from one feature to another.
  - Baseline dimensions are referenced from a common feature or surface
  - When choosing a system of dimensioning, be aware of tolerance stack-up

Chain vs. Baseline Dimensioning

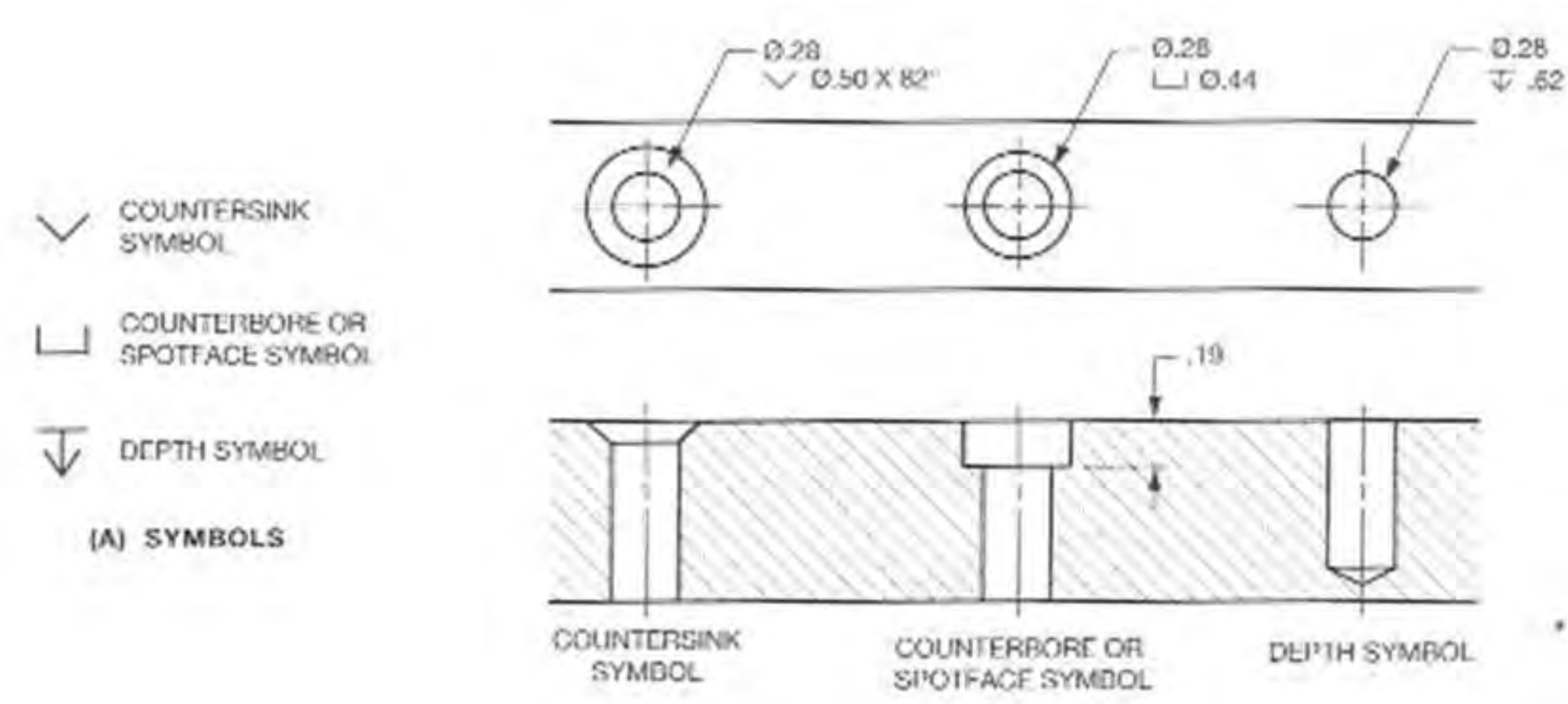
- Exercise - Calculate tolerance stack-up



Dimensioning Hole Features

- Countersinks
  - Dimensioned with the diameter of the hole, then countersink, then angle of countersink
- Counterbores (Spot Face)
  - Dimensioned with the diameter of the hole, then counterbore, then depth of counterbore
- Clearance Hole
  - A hole slightly larger than the nominal size of item using the hole (bolt, screw, shaft, pin, etc)

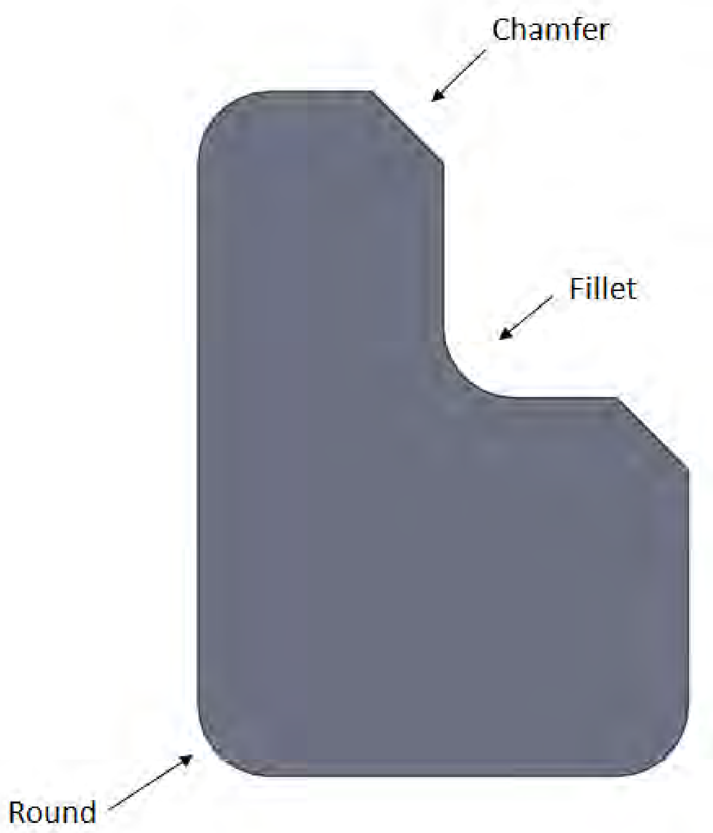
Hole Features



Rounds, Fillets, and Chamfers

- Rounds
  - External intersection of faces that are rounded
- Fillets
  - Internal intersection of faces that are rounded, where material is added to an otherwise square corner
- Chamfers
  - Intersection of faces that is cut away to make an angular feature

Rounds, Chamfers, and Fillets



What Does This All Mean?

- Drawings

3D Modeling Overview

What are 3D Models?

- 3D Modeling is the process of developing a mathematical, wireframe or multi-faceted surface representation of any three-dimensional object via specialized software.

What are 3D Models?

- 3D models are three-dimensional representations of a parts or assemblies that you wish to create. Unlike 2D drafting tools, 3D modeling technology provides a lifelike representation of a design, from structural composition and the way parts fit and move together, to the performance impact of characteristics such as size, thickness, and weight.

The Benefits of 3D Modeling

- Fully defined and detailed three-dimensional models and assemblies
  - ability to understand the way things interface with one another
- Interference checks
  - 3D assemblies can be rotated around to check for interferences, clearances and other concerns
  - Automated interference checks

The Benefits of 3D Modeling

- Design flexibility and ease of modification
  - With 3D models, most dimensions and relations are associative, meaning if you change one dimension, the remaining dimensions and mating parts will move accordingly-VERY important
- Hardware Libraries
- Mass properties
- Strength and force analysis (FEA)

Software Programs

- Commonly used 3D modeling programs
  - SolidWorks
  - Pro/Engineer
  - Autodesk Inventor
  - Autodesk AutoCAD (has minor 3D capabilities)
  - Catia
  - Unigraphics
  - Solid Edge

Good Modeling Practices

- While following tutorials and taking classes to learn how to use a specific 3D Modeling packages important, it is also equally as important to learn and use good modeling practices. Good modeling practices are universal and can be carried across all platforms and programs. These practices ensure that some common train of thought was used when creating and editing models, so that if someone else needs to modify it or rework it, the design intent is clear and that the model tree and overall part are laid out in a logical and sensical way.

Design Intent

- Top Down vs. Bottom Up
  - Top-down and bottom-up are strategies of information processing and knowledge ordering, mostly involving software, but also other humanistic and scientific theories
    - In practice, they can be seen as a style of thinking and teaching
    - In many cases top-down is used as a synonym of analysis or decomposition, and bottom-up of synthesis

Top Down Modeling

- A top-down approach is essentially breaking down a system to gain insight into its compositional sub-systems
  - An overview of the system is first formulated, specifying but not detailing any first-level subsystems
  - Each sub-system is then refined in yet greater detail, sometimes in many additional subsystem levels, until the entire specification is reduced to base elements

Bottom Up Modeling

- A bottom-up approach is piecing together systems to give rise to grander systems, thus making the original systems sub-systems of the emergent system
  - In a bottom-up approach the individual base elements of the system are first specified in great detail
  - These elements are then linked together to form larger subsystems, which then in turn are linked, sometimes in many levels, until a complete top-level system is formed

Bottom Up Modeling

- This strategy often resembles a "seed" model, whereby the beginnings are small but eventually grow in complexity and completeness. However, "organic strategies" may result in a tangle of elements and subsystems, developed in isolation and subject to local optimization as opposed to meeting a global purpose
- Bottom Up strategies are typically not used in industry where overall size, weight, and cost constraints exist
- Top Down philosophy is preferred in most vehicle design
  - Sub-System division on FIRST robots is very similar to vehicle design (Powertrain, Chassis, etc.)