ENGINEERING COMMUNICATION -- DRAWINGS

ME 482 Senior Design II

Spring 2024

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adapted from a presentation by

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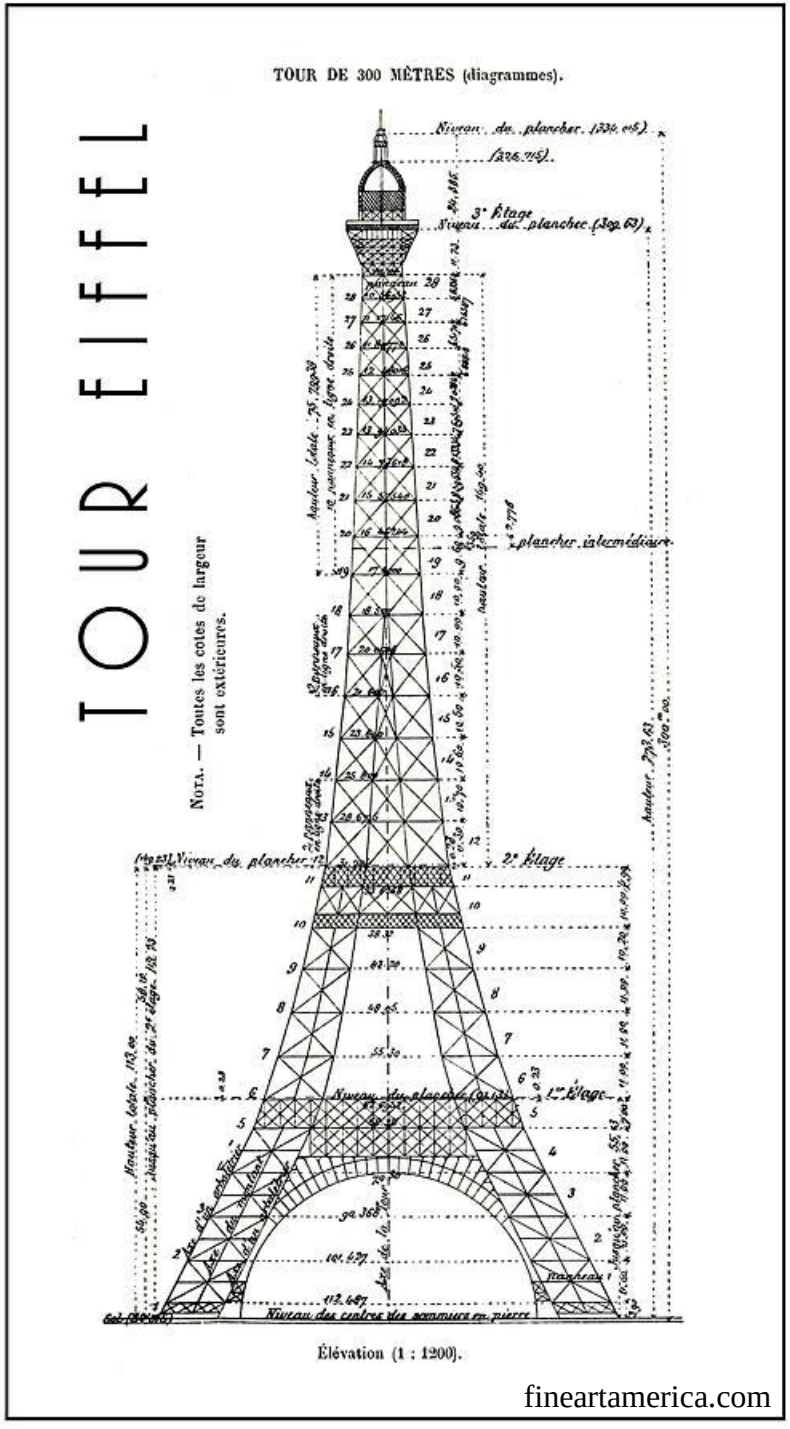
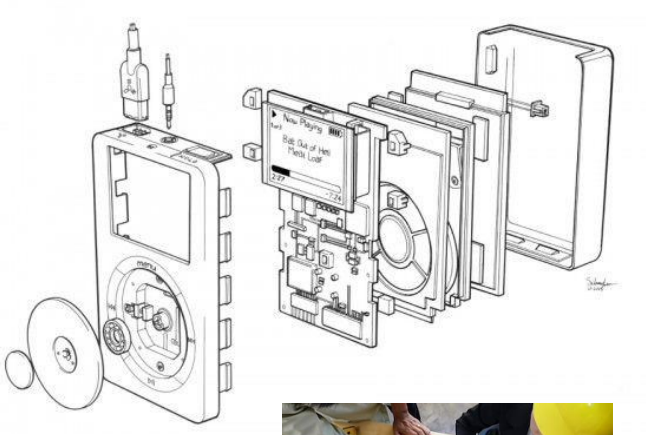


Engineering Drawing

- A form of visual communication
- Common language of engineering
- A method of transferring ALL needed information from design into manufacture



- Effective and efficient way to communicate:
  - Engineering requirements (Customer → Engineer)
  - Proposals (Engineer → Customer)
  - **Design intent (Engineer → Manufacture)**
  - Instructions (Engineer → User)

Design Intent

- **Purpose: Building intelligence into the model**
- Governs how features are **intended** to be related with each other
- With good design intent, models can be updated almost effortlessly

> "… a detailed explanation of the ideas, concepts, and criteria that are defined by the Owner to be important;
> … even when you have a full geometric description of an object you may NOT know why something is designed to be like it is."
>
> - P.Y. Papalambros, *J. Mech. Des.* 2010

- Example 1: A CAD model from reverse engineering a 3D laser scanner
  - No, do not contain any information about their design intent
  - Not record relationship between sub-parts or a construction sequence
- Example 2: Transferring a model from one CAD system into another
  - Maybe, often does not transfer design intent
  - May result in approximate models due to different model representations and tolerance systems.

Legal Contracts

Engineering drawings are legal contracts

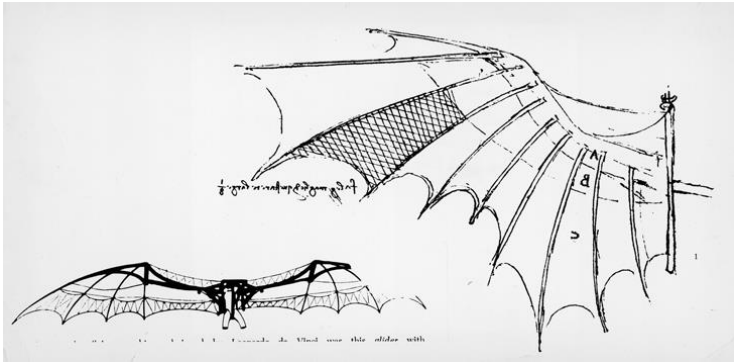
- If the product is wrong, manufacturer is protected from liability as long as he/she has faithfully executed the drawing instructions.

- Creation and maintenance of them are, and should be, expensive and time consuming
- Drawings should communicate all the needed information about "what is wanted"
- No ambiguity
- Not open to interpretation

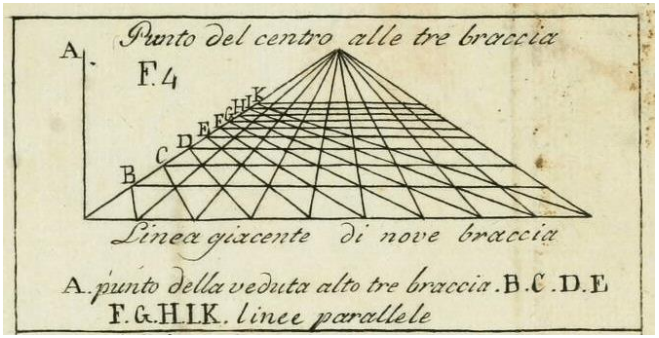
Tolerancing.net

Early Engineering Drawing Pioneers

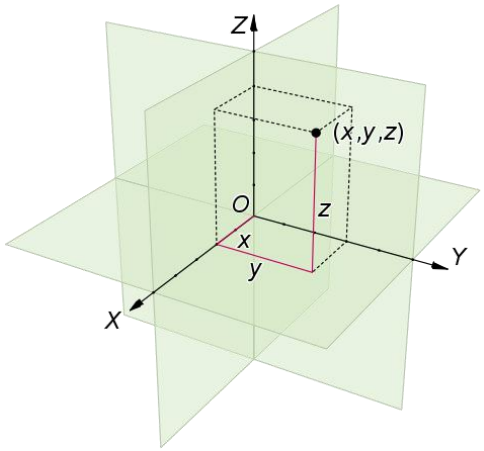
- Leonardo da Vinci (1452 - 1519)
  - Created pictorial drawings
  - Without dimensions



- Leon Battista Alberti (1404 - 1472)
  - Needs for geometry in drawing
  - Drawings with multiple views

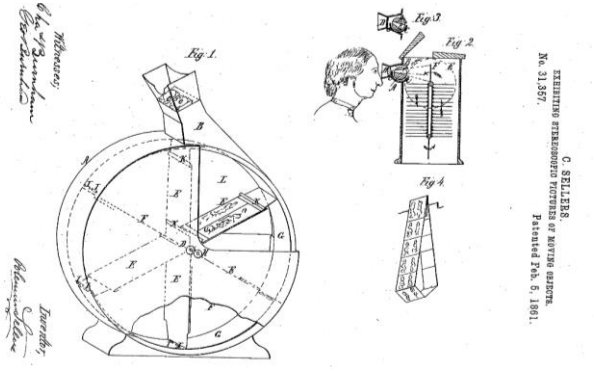


- René Descartes (1596 - 1650)
  - Invented Cartesian coordinate system
  - Founder of analytic geometry

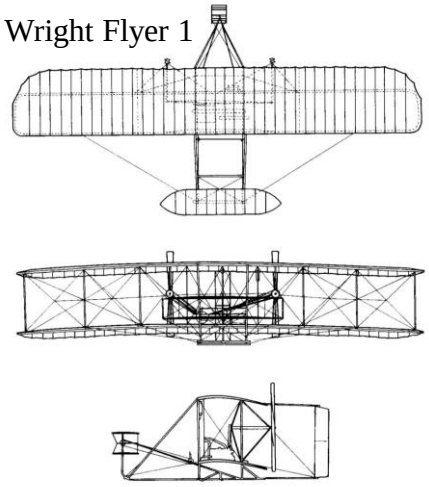


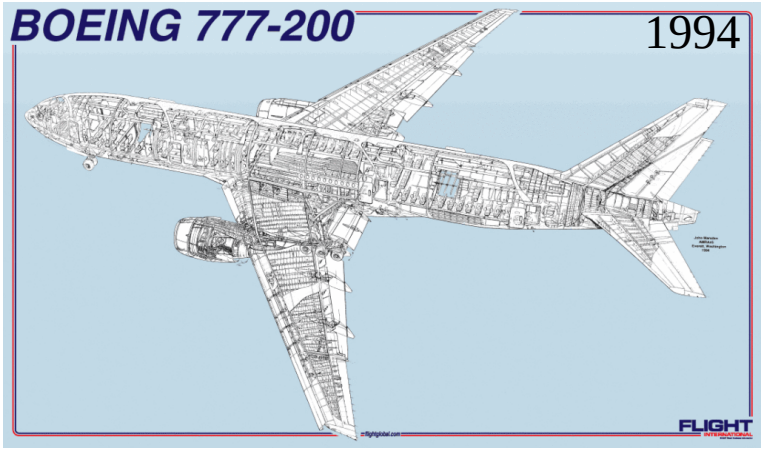
Evolution of Engineering Drawing

- Pre-industrial revolution
  - Parts from hand sketches and drawings
- Post-industrial revolution (19th Century)
  - Interchangeability became important
  - Requires accurate drawing
  - Engineering drawing evolves rapidly
- From hand practice to CAD (1960 – 21st C)



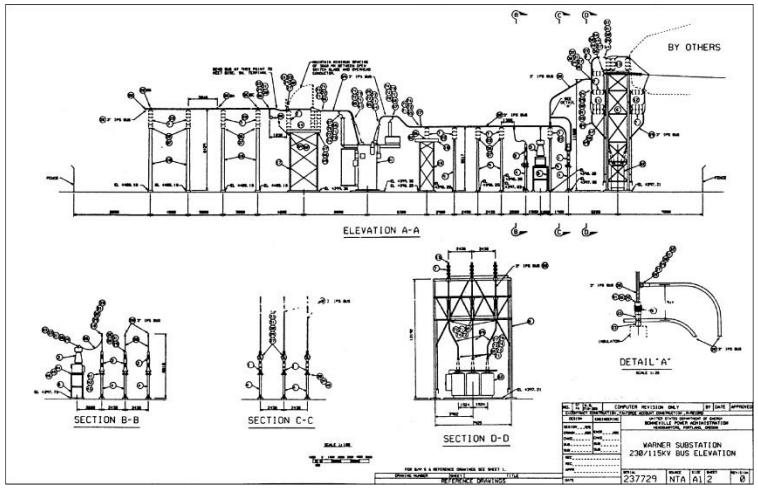
1903 Wright Flyer 1

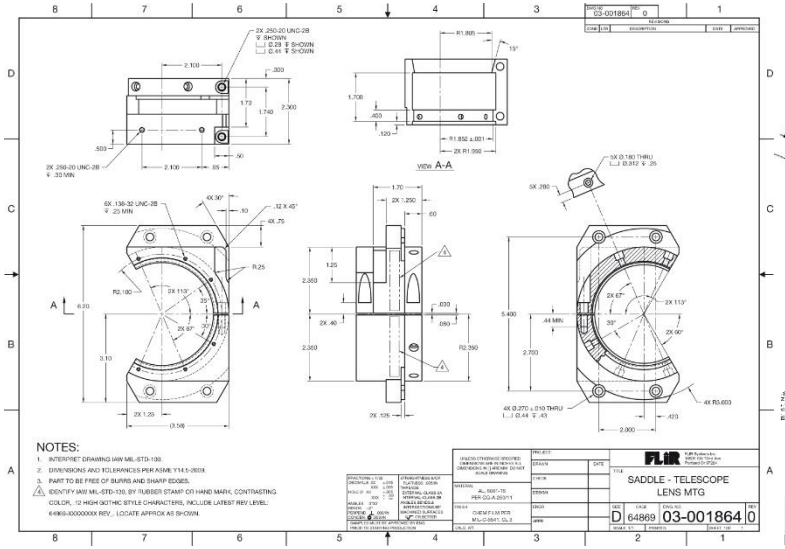


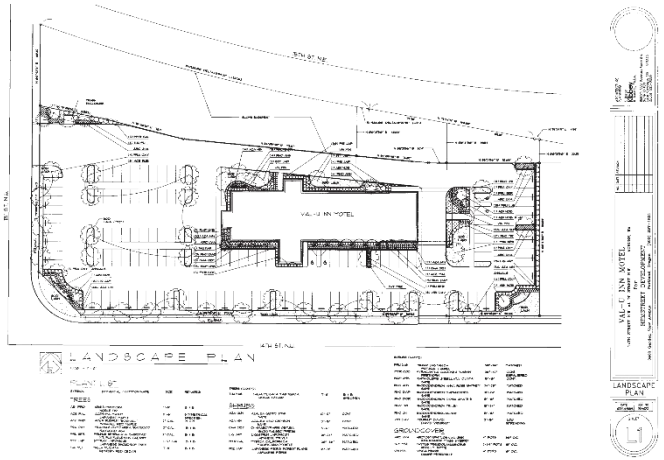


Types of Engineering Drawing

- Cartographic
- Electrical
- Electronics
- Civil
- Architectural
- HVAC
- Landscape
- Mechanical
- (...)







Tools for communication

Requires worldwide, standardized drafting practices

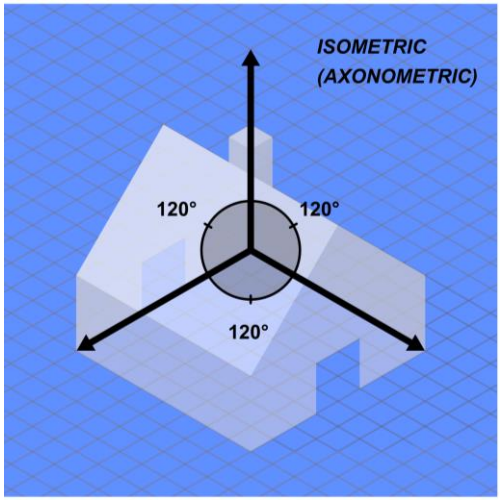
Engineering Drawing Standards

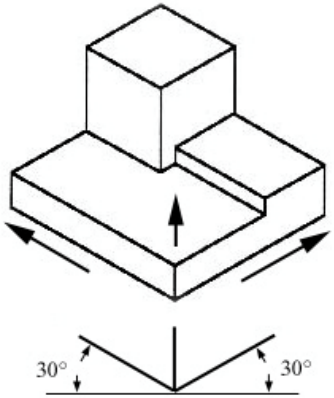
- Standards provide rules for specification and interpretation
- Standardization aids internationalization
- ANSI (ASME) vs. ISO

- Drawing Concepts Overview
  - Isometric Drawing
  - Multiview (Orthographic) Drawing
  - Sectioning
  - Dimensioning

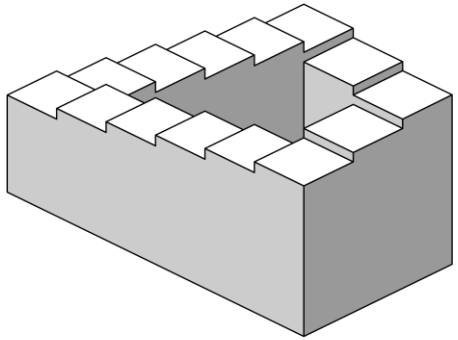
Isometric Drawing

- Method for representing 3-D in 2-D.
- It is an axonometric projection in which the three coordinate axes appear equally foreshortened and the angle between any two of them is 120 degrees.





E.E. Blanco et al.

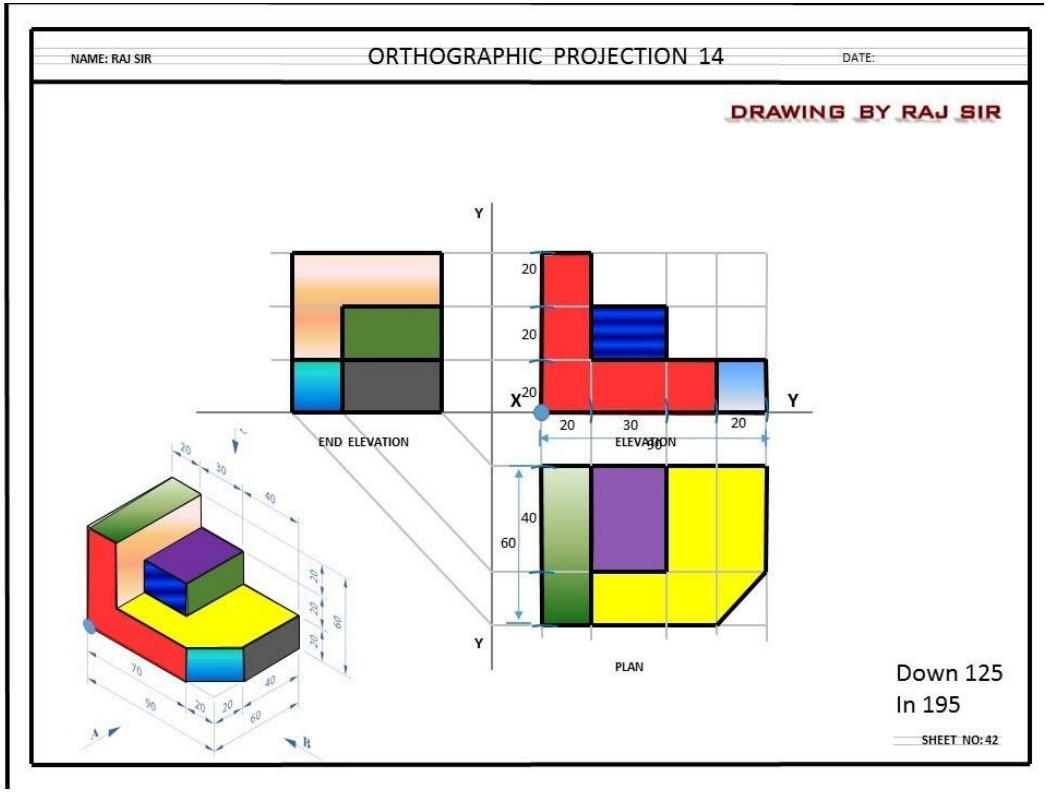


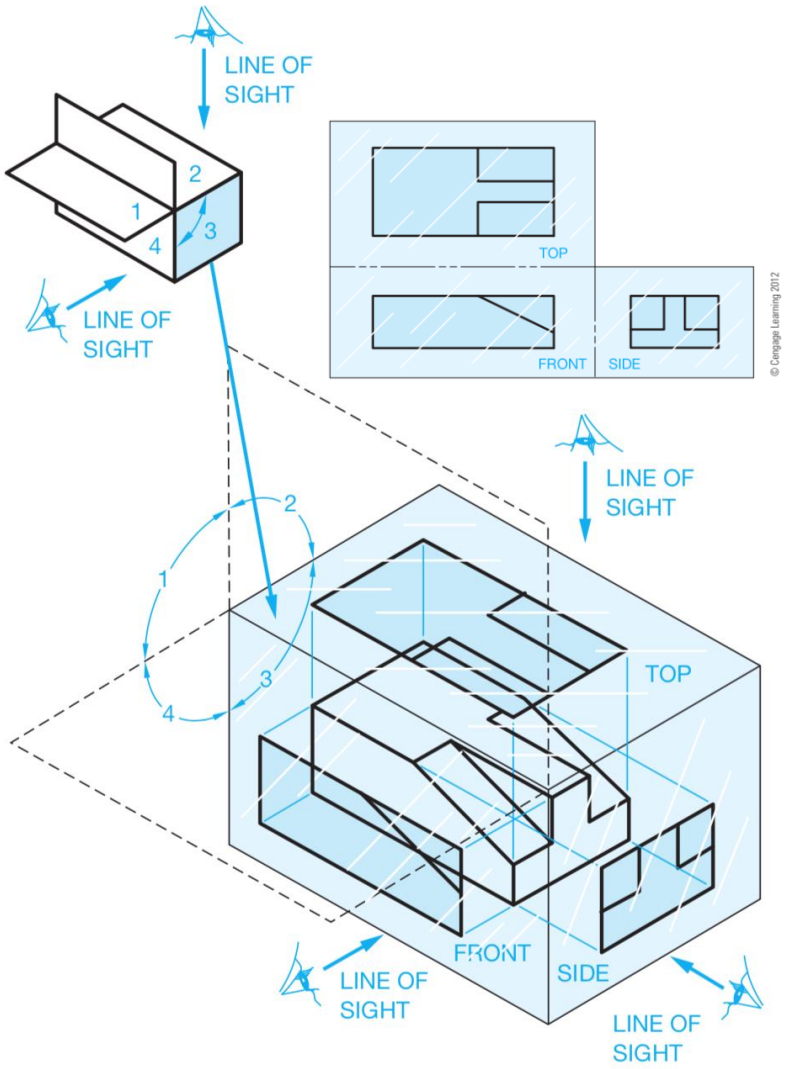
Wikipedia.org

- Any engineering drawing should show everything
- A complete understanding of the object should be possible from the drawing

Multiview (Orthographic) Projection

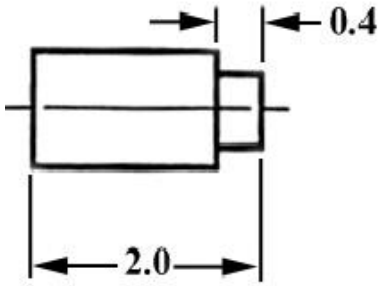
- Orthographic projection: System for drawing and dimensioning complex three-dimensional items
- From 3D designs to 2D drawings
- View from orthogonal planes

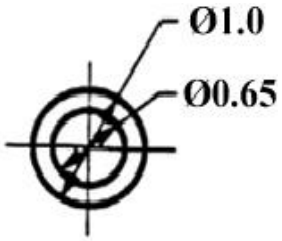


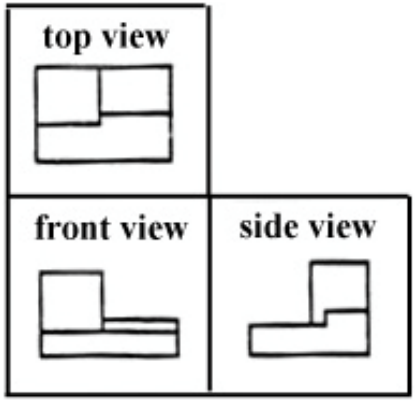


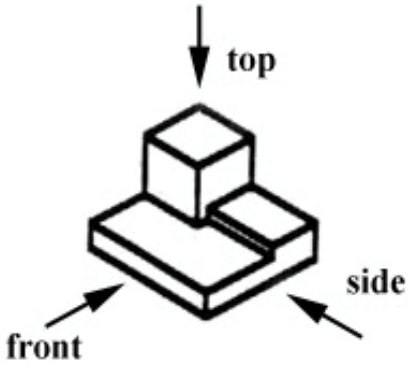
How many views?

- Does it have to be three?







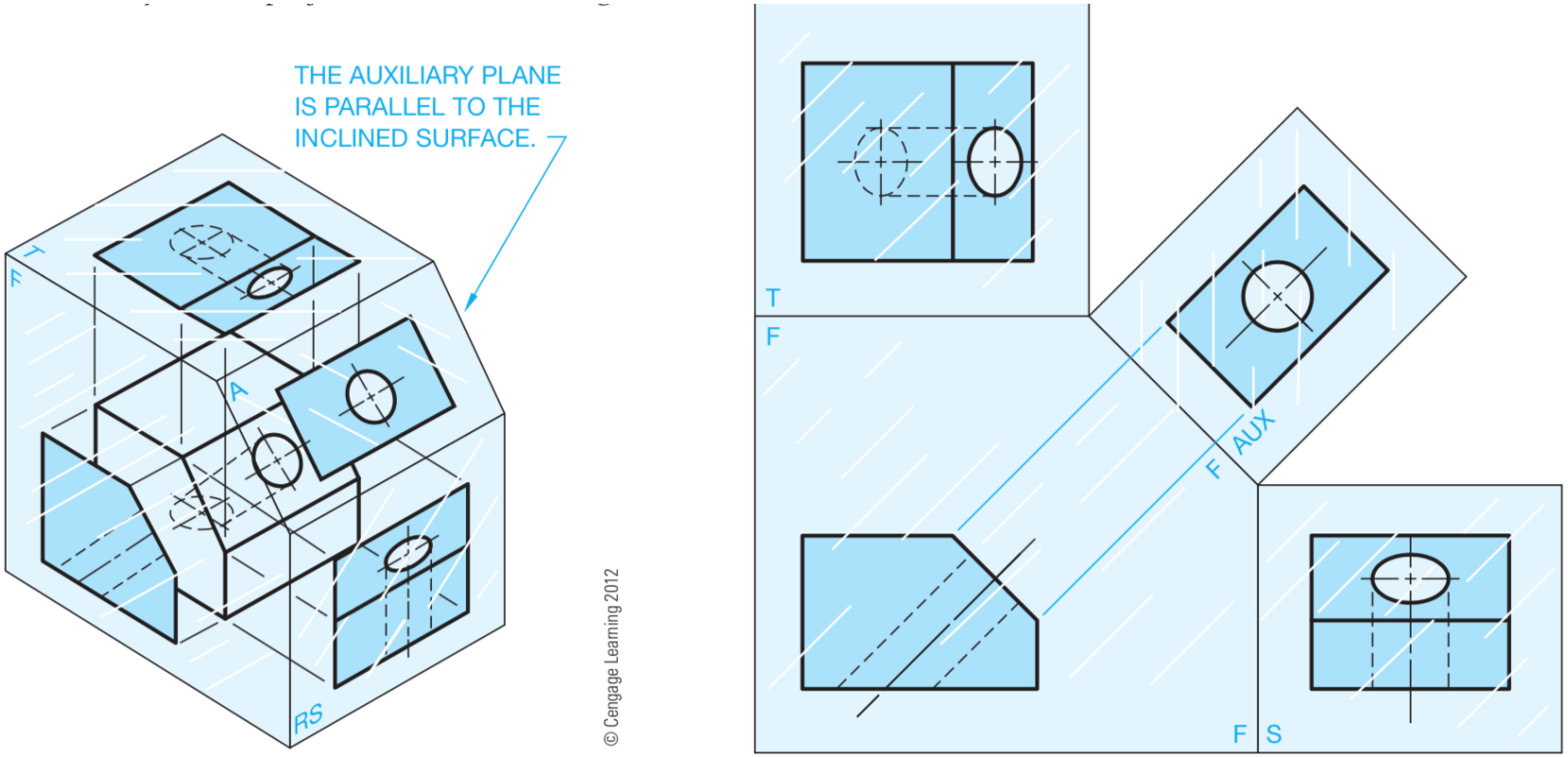


- Six principal viewing planes:
  - Front, top, right-side, left-side, bottom, rear

- Need as many views as are required to fully described the object

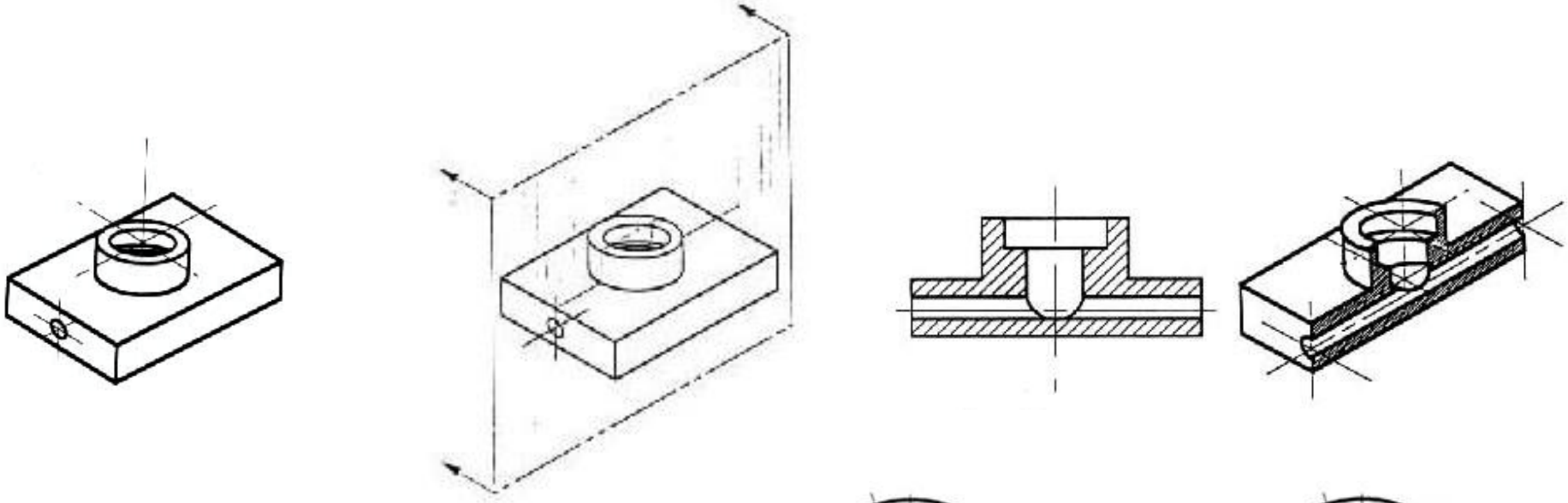
Auxiliary Views

- Parts with surface(s) not parallel to any of the six principal viewing planes
- Allow for inclined planes (and any other significant features) to be projected in their true size and shape

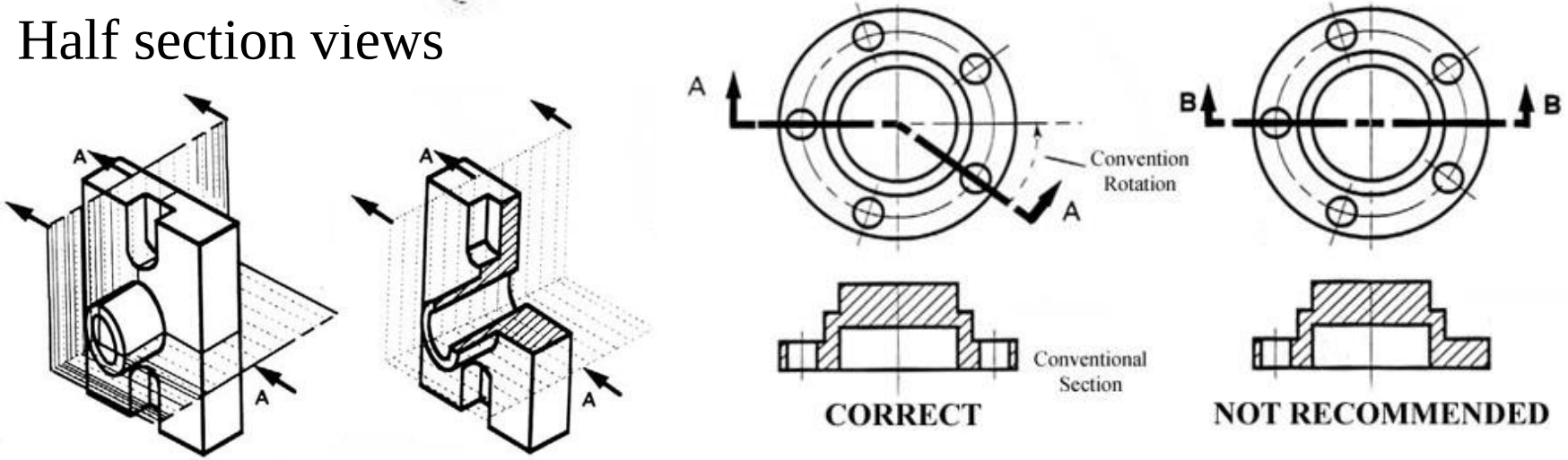


Sectioning and Section Views

- Used when interior details cannot be seen from the outside

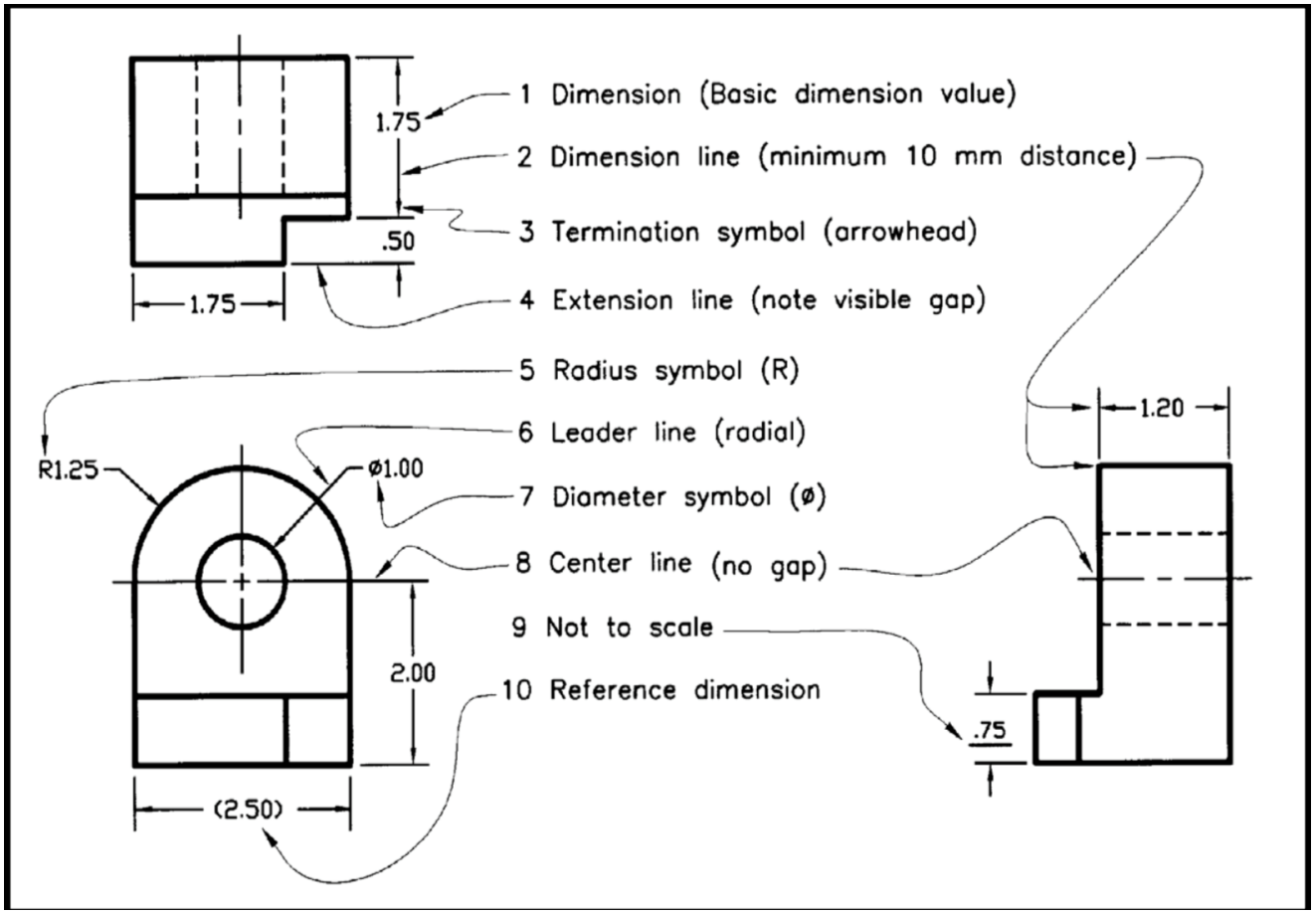


- Half section views



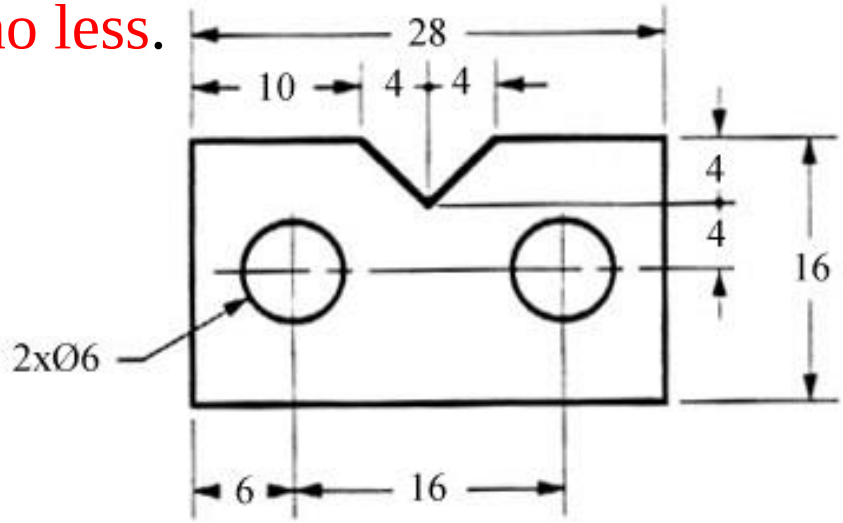
Dimensioning

- A dimension is for size and position
- Different kinds: Linear, aligned, angular, radius/diameter, reference etc.



Rules for Dimensioning

- **Accuracy**: correct values must be given.
- **Clearness**: dimensions must be placed in appropriate positions.
- **Completeness**: nothing must be left out, and nothing duplicated.
- **Readability**: the appropriate line quality must be used for legibility.
- Put in exactly as many dimensions as are necessary for the craftsperson to make it - no more, no less.



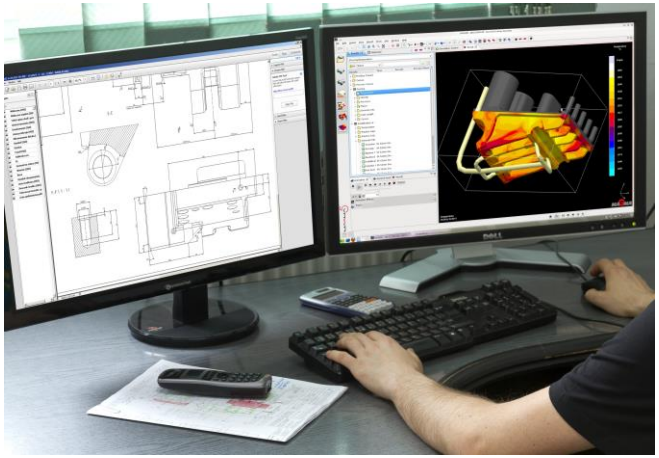
- No redundant dimensions
  - clutter the drawing
  - often lead to conflicts when tolerance allowances can be added differently

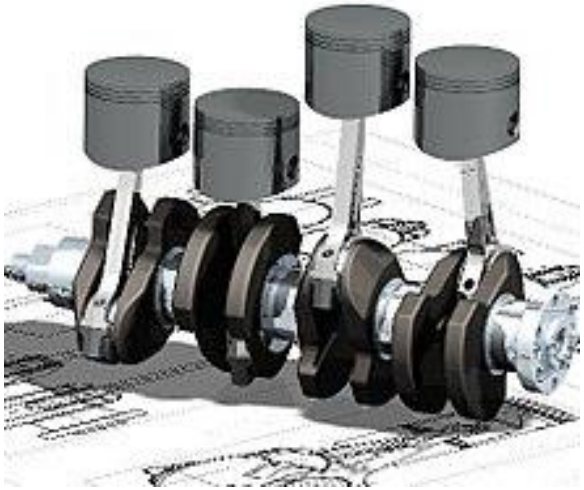
CAD

- It’s not a computer game!
- Suppose to facilitate the expression of design intent

Common CAD Software Manufacturers

- Alibre, Inc.
- Ashlar-Vellum
- Autodesk, Inc.
- Bentley Systems, Inc.
- Dassault Systèmes
- Google Inc.
- GRAPHISOFT
- IMSI/Design, LLC
- Intergraph
- IronCAD
- Kubotek Corporation
- Parametric Technology Corporation
- Siemens Corporation
- Solidworks

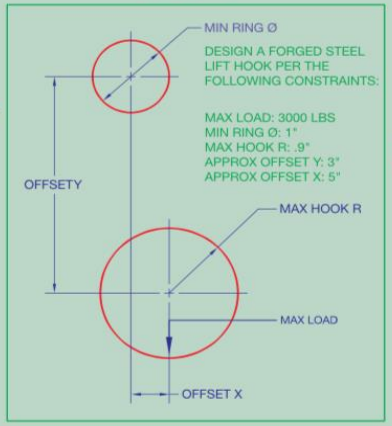




The Engineering Design Process

(Integrated with CAE)

STEP 1



PROBLEM STATEMENT

STEP 2

INITIAL SKETCH

STEP 3

INITIAL CADD MODEL

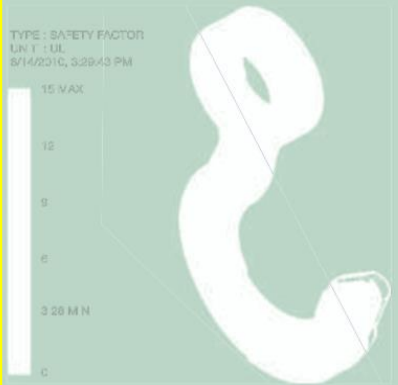
STEP 4

INITIAL FEA

STEP 5

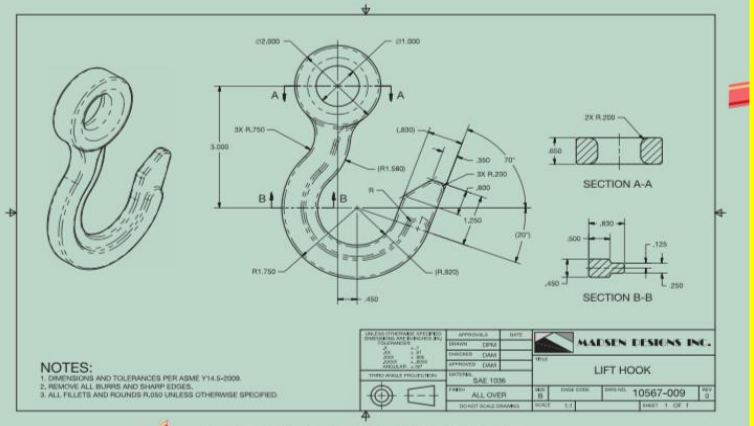
DESIGN OPTIMIZATION

STEP 6



FINAL FEA

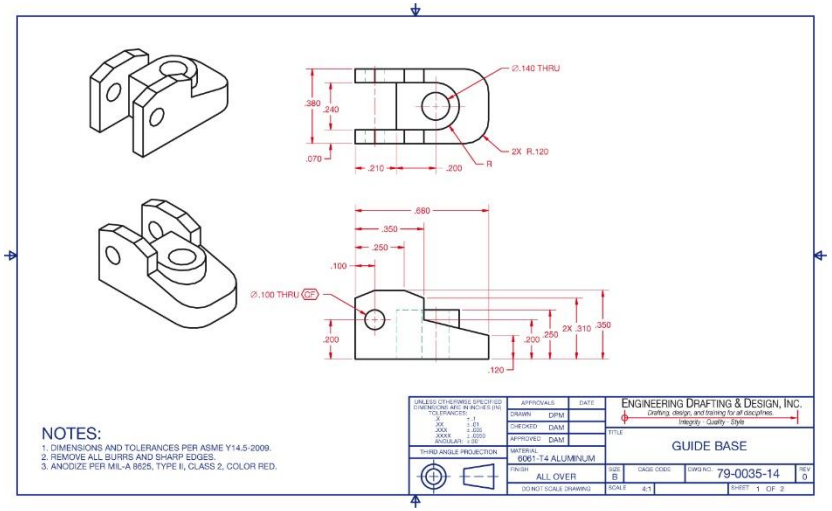
STEP 7



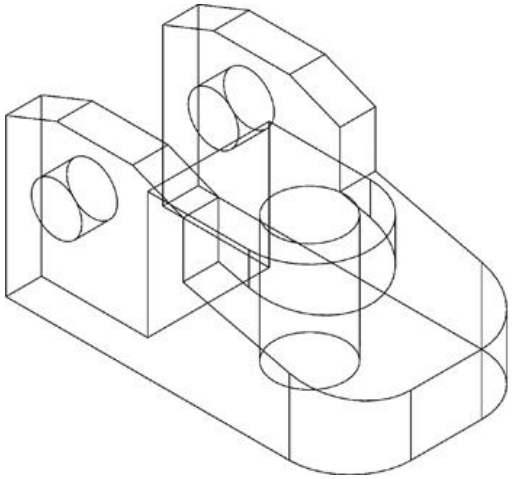
DESIGN DELIVERABLES

Common CAD Formats

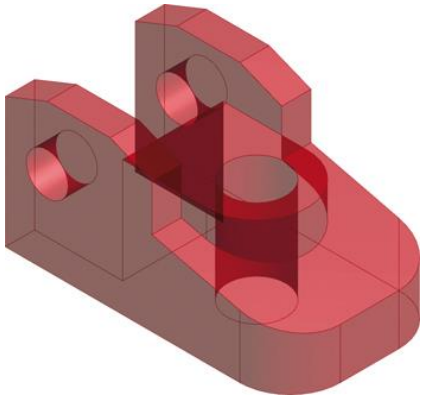
- 2-D Drawings



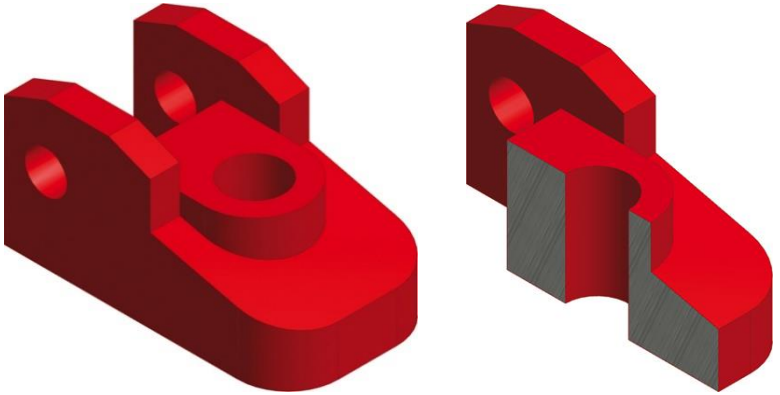
- 3-D Wireframe Model



- 3-D Surface Model

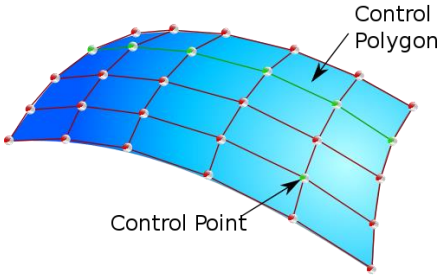


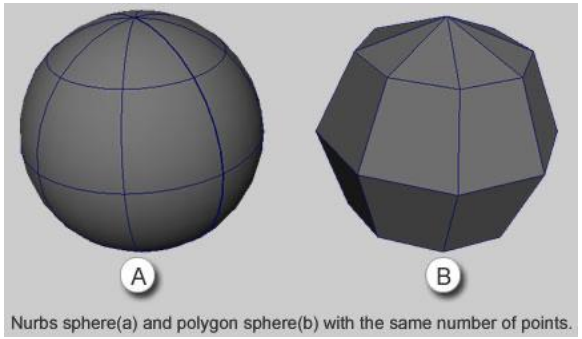
- 3-D Solid Model



Surface Modeling Techniques

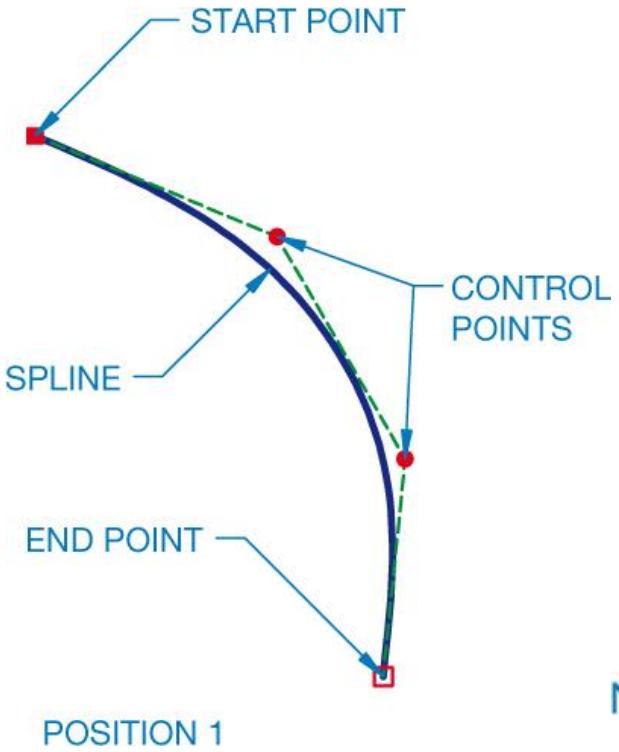
- Polygon

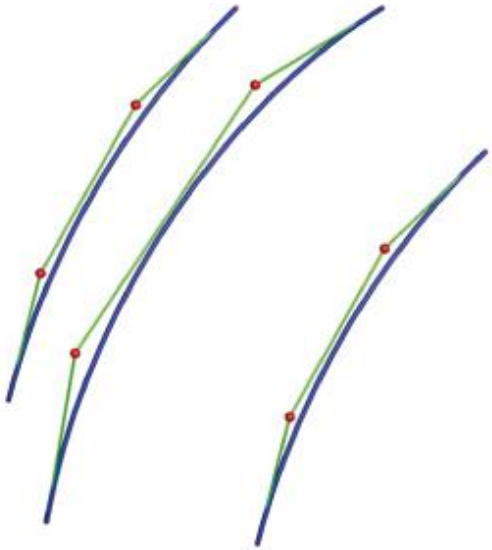


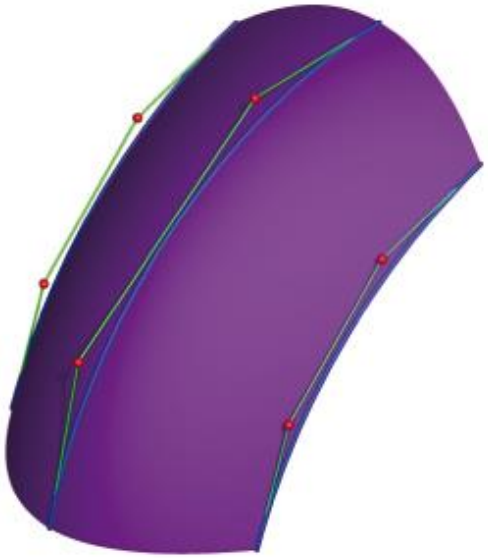


Nurbs sphere(a) and polygon sphere(b) with the same number of points.

- Non-uniform rational basic spline (NURBS)

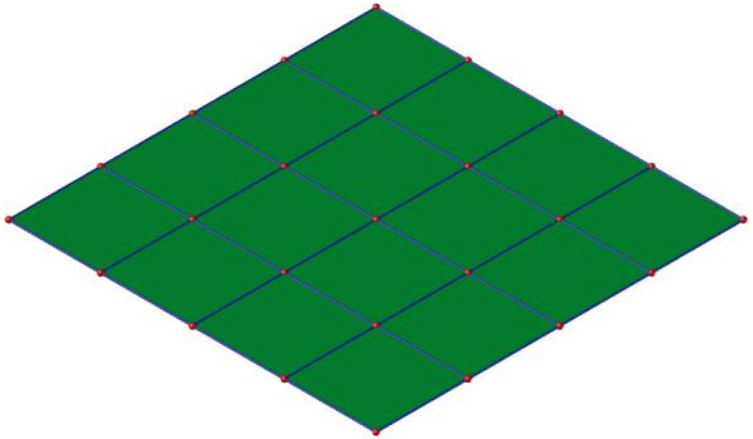


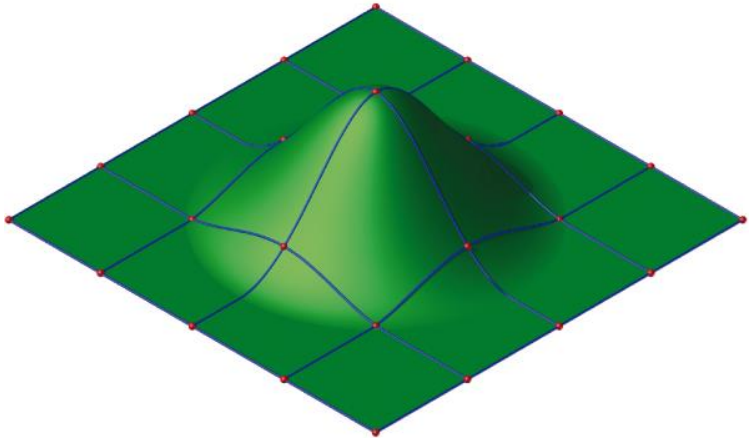

NURB CURVE CONSTRUCTION
POSITION 2


NURB SURFACE DESIGN

Creating Surfaces

- Direct surface modeling

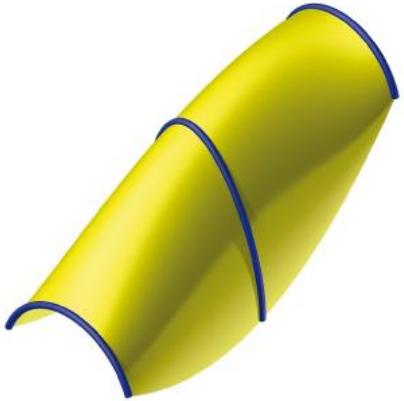




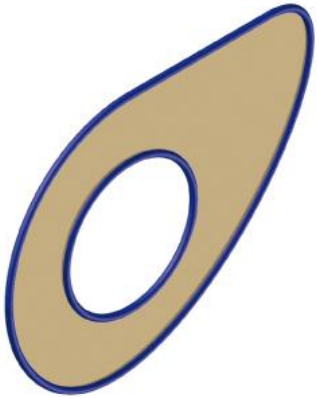
- Procedural surface modeling

EXTRUDE

SWEEP



LOFT



BOUNDARY PATCH

Conclusions

- Engineering drawing is a vital form of communication
- Engineering drawings are legal documents
- Key is to capture design intent
- Should contain all vital information for production
- CAD software should only facilitate instead of replace design