3D MODELING & VIEWING

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INTRODUCTION

- In this our first goal is to create a geometric model of an object.
- So that the model serves as a digital representation in computer later we can use for a variety of engineering activities such as analysis and manufacturing.
- The representation is well structured in the model database, and the database structured content stored in the part file.

MODELING APPROACHES

- CAD designers can create models in different ways.
- **Three modeling approaches** that designers can choose from to create solid models
  - Primitives , Features, and Sketching.
- The existence of the three approaches is attributed to evolution of solid modelers.
- As science and technology advanced, features along with the primitives became available.

PRIMITIVES APPROACH

- The primitives approach views a solid model as a combination of simple, generic, and standard shapes that can be combined.
- These shapes are the primitives. Primitive are include a block(box), cylinder, sphere, cone, wedge, and torus.
- These primitives are combined via the Boolean operations like union, subtraction, and intersection.

FEATURES APPROACH

- The features approach is similar to the primitives approach ; it replaces primitives with features and embeds Boolean operation in the feature definition.
- <u>For example:</u>

  let us consider creating a hole in a block

1. Create the block using a block primitive
2. Create a cylinder in the right location and orientation relative to the block.
3. Subtract the cylinder from the block

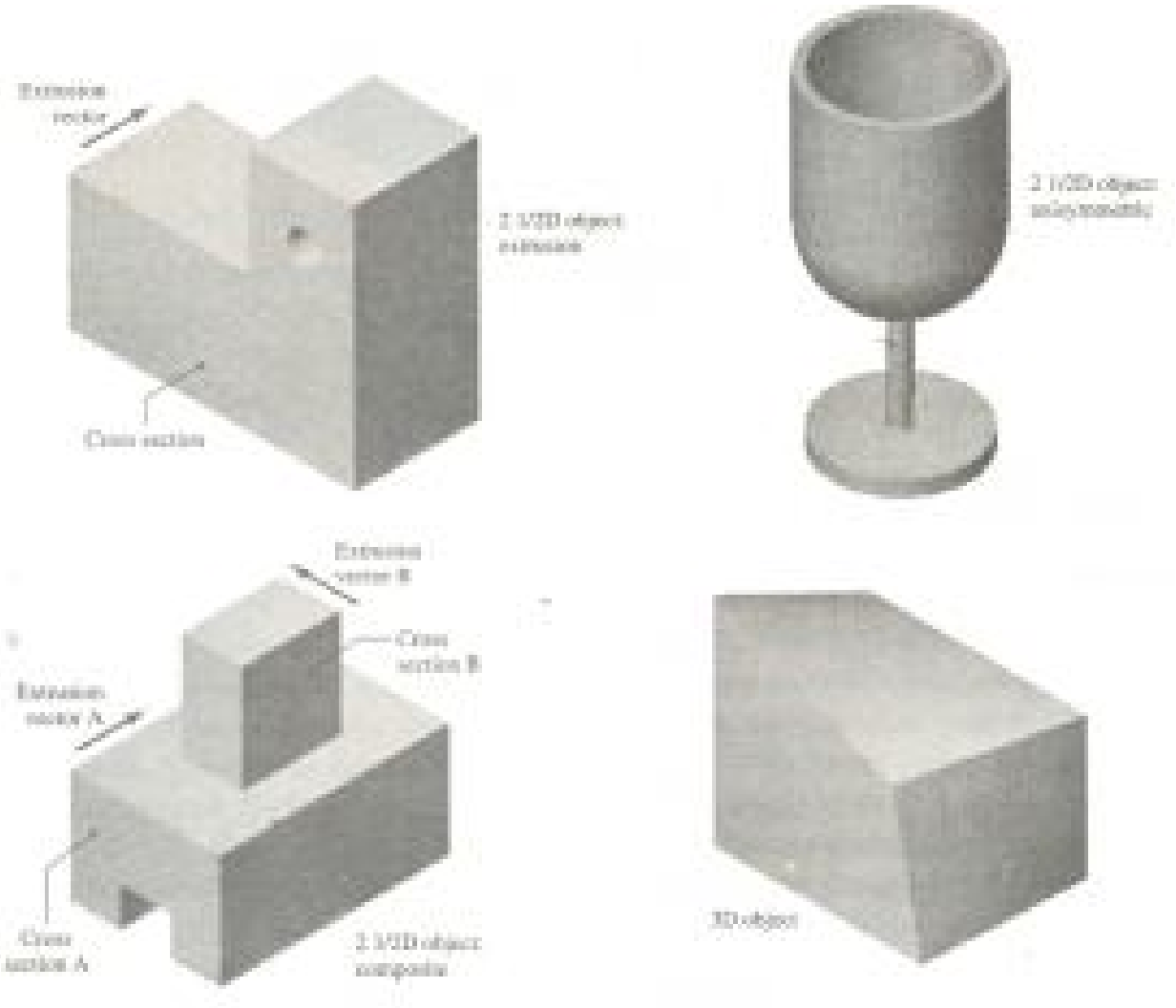
SKETCHING APPROACH

- The sketching approach is similar to features approach with one change, instead of using predefined shapes only, such as holes and ribs.
- It allows for CAD designers to create much more elaborate and more general features starting from sketch.
- Examples, include extrusion, revolution, linear and non linear sweep, loft, spirals and helices.
- The sketching approach utilizes the following steps to create any feature.

1. Select or define a sketch plane.
2. Sketch 2D profile.
3. Modify sketch dimensions and update sketch.
4. Create the feature.

TYPES OF GEOMETRIC MODELS

- Objects and their geometric models and can be classified into three types from geometric construction point of view. These are 2½ D, 3D or a combination of both.
- 2½ D objects are further classified into three subtypes: extrusions, axis symmetric and composite.
- A 3D object is one that does not have any geometric uniformity in any direction .
- Construction 21/2D objects requires only constructing the proper cross sections and projecting them along the proper direction by the thickness value.



COORDINATE SYSTEM

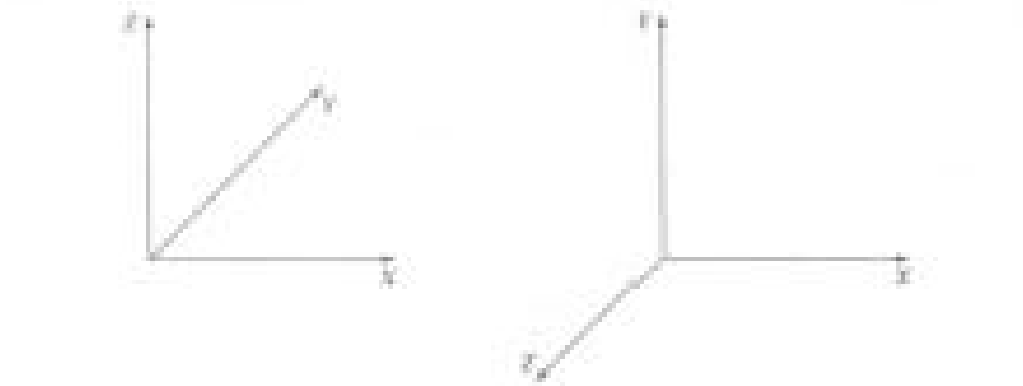
- Three types of coordinate systems are needed in order to input, store, and display model geometry and graphics. These are :
  - Model Coordinate System (MCS)
  - Working Coordinate System (WCS)
  - Screen Coordinate System (SCS).

MODEL CO-ORDINATE SYSTEM - MCS

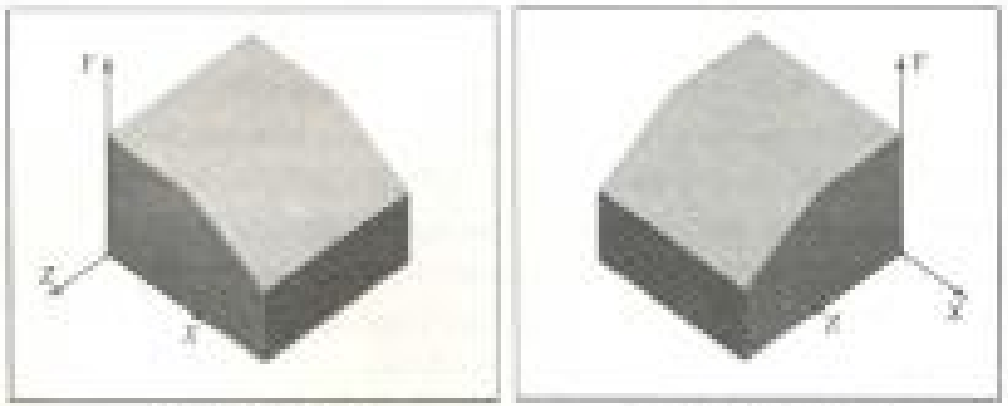
- The MCS is defined as the reference space of the model with respect to which all the geometrical data is stored. It is a Cartesian system which forms the default coordinate system used by a particular software program.
- The X,Y, Z axis of the MCS can be displayed on the computer screen
- The origin of the MCS can be arbitrarily chosen by the user.

MODEL CO-ORDINATE SYSTEM - MCS

- The three different sketch planes of CAD/CAM system defined the three planes of MCS, which are :
  - XY plane is the horizontal plane and defines the model Top View
  - XZ plane is the Front View
  - YZ plane is the Side View
- Existing CAD/CAM systems uses the MCS as the default WCS and the XY plane is the default construction(sketch) plane



(a) XY plane defines model top view (b) ZY plane defines model front view



Orientation ❶ Orientation ❷

WORKING COORDINATE SYSTEM - WCS

- It is often convenient to develop the geometric models and the input of geometric data by reffering to an auxiliary coordinate system which is WCS
- The WCS can be established at any point and orientation in space that the user desires.
- WCS requires three non collinear points to define its XY-plane
  - First defines the origin, the second defines the X-axis and the third defines the Y-axis
- The ability to use two separate coordinate systems within the same model database in relation to one another gives the user great flexibility
- There is only one active WCS(sketch plane) at one time. If more multiple WCSs are defined, the software recognizes the last one and stores it with the model database.

SCREEN COORDINATE SYSTEM - SCS

- SCS defined as 2D device dependent coordinate system whose origin is usually located at the lower left corner of the graphics display.
- The SCS is mostly used in view related clicks such as definitions of view origin and window or clicking a view to select it for graphics operations
- The range of the SCS can be chosen from(0,0) to (1,1) which can be translated by device dependent codes to the appropriate physical device coordinates
- SCS also can be defined by using drawing size that the user chooses
- A transformation operation from MCS coordinates to SCS coordinates is performed by the software before displaying the model views and graphics
- There is a data structure to store its geometric data (relative to MCS) and a display file to store its display data (relative to SCS)

SKETCHING AND SKETCH PLANES

- CAD designer defines the sketch plane, it involves the sketcher of the CAD system like pro/e, solid works to create geometry and solid models.
- Sketchers provide CAD designers with sketching entities and tools like lines, circle……..
- Sketchers are designed to read the designers mind like when a designer moves the cursor near a line the sketcher flash the end point or mid point depending on which point is closed. It also creates perpendicular as in case of define to datum axis
- Sketchers use color codes to display sketch geometry to alert designers ie. A sketch can exist in one of three states
  - Under defined sketch - in Blue – additional dimensions are required
  - Fully defined sketch – in Black – no additional dimensions are required
  - Over defined sketch – in Red – contains conflicting dimensions / relations

PARAMETERS AND DIMENSIONS

- CAD designer can easily modified the concept of parameters area model is parameterized automatically by CAD/CAM system during construction.
- The designer can simply change the values of parameters and ask the CAD/CAM system to regenerate or recreated the model.
- The sketch parameters and dimensions work together . Parameters are the generalization of the sketch definition they create a template of the sketch.
- Dimensions are the specifications of the sketch definition they create is specific instant of it.

PARAMETERS AND DIMENSIONS

- There may be multiple ways to parameterize the same sketch
  - Geometric and topological constraints
  - Relations between the sketch entities in addition to its geometry
    - Like $P_3 = 0.5P_1$, $P_4 = 0.5P_2$, $P_5 = 0.25P_1$, in addition, perpendicular or parallelism constraints between the sketch entities
- Unigraphics and CATIA allow designers to define relations and constraints mannually
- Pro/E and SolidWorks use the automation approach
  - ie . After creating a sketch, the designer adds dimensions to it and modify it to generate the entire sketch for final dimensions
- The sketch parameterization offers a great design tool for CAD designers and they can freely sketch their ideas without having worry about dimensions. The steps are *Generate Parameters(via sketching) =>Assign Dimensions => Regenerate*

BASIC FEATURES

- The analysis of existing CAD/CAM systems reveals that they all offer a basic set of features . This basic set includes following features
  1. Extrusion
  2. Revolution
  3. Hole
  4. Cut
  5. Sweep
  6. Loft
  7. Fillet
  8. Chamfer
  9. Rib
  10. Shell
  11. Draft
  12. Pattern
  13. spiral
  14. helix

DATUM FEATURES

- Creation of solid model begins with a sketch that is used in conjunction with a feature operation to create features
- Reference geometry is a special type of geometry i.e used to define other geometry. It is not ordinary geometry
- This reference geometry comes in the form datum features. CAD systems allowed designers to create these type of datum features like .

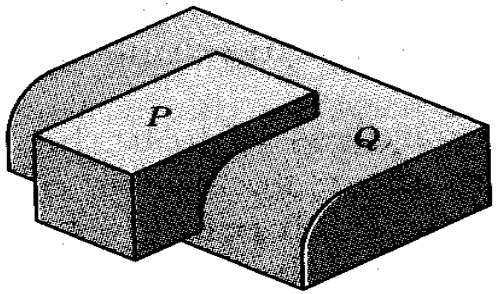
1. Datum plane – used when a non standard sketch plane is needed
2. Datum axis – ex. Axis of revolution for circular features
3. Datum curve – point feature – to create curves
4. Datum coordinate system
    1. used temporarily for mass properties calculation
    2. Uses to export documents to IGES, STL, STEP or other formats

GEOMETRIC CONSTRAINTS

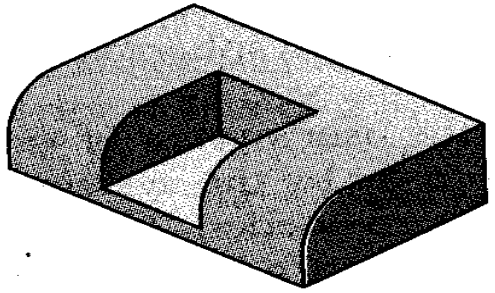
- Length equals other
- Hole in a rectangle
- Hole is always in the centre of the rectangle
- Parallel sides
- perpendicular

MODELING OPERATIONS

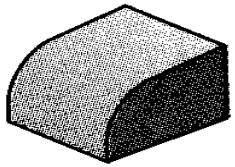
- Union – add
- Subtraction - cut
- Intersection



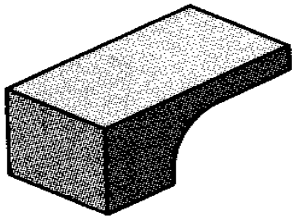
Union $(P \cup Q)$



Difference $(Q - P)$



Intersection $(P \cap Q)$



Difference $(P - Q)$

MODELING STRATEGIES

- Planning is a sequence of thoughts about the best, easiest and fastest way to create the geometric model of the object. This strategy may change when execution.
  - Determine model type and sub type
  - Observe geometric characteristics of model
  - Choose model orientation in 3D space – top,bottom, front etc.
  - Decide on other geometric details – modifications, color etc..
  - Avoid unnecessary calculations