**Basic Modeling Techniques**

- Create model full-size (full scale)
  - Since no internal units, no reason to consider any scale other than full
- Geometry **must be** accurate
  - Inaccurate features dimensions will complicate downstream tasks such as the creation of mechanical drawing, analysis and manufacturing

**Solid Modeling**

- Effective use of a solid modeling system requires:
  - 3D visualization skills
  - Understanding of solids construction concepts
  - Understanding model structure in order to effectively use model editing techniques

**Basic Modeling Techniques**

- Model definition must be complete
  - However, note that completeness based upon model type and application
- Level of detail must reflect application
  - greater number of entities, more computationally expensive, will take longer for model database to regenerate

**Solid Modeling Techniques**

- Typically advantageous to add material before removing material. For example,
  - Use "protrusion" type operations first
  - Use "cut", "slot", "hole" type operations next
  - Often advantageous to create solid **rounds** before creating solid **fillets**

**Solid Modeling Techniques**

- Keep geometry simple
  - Use many simple features rather than few complex ones
  - Use the simplest feature type to accomplish creation
    - extrudes rather than more complex sweeps
    - sweeps rather than lofts if practical
  - A model consisting of multiple simple features is easier to edit than one that consists of a few complex features.
Sweeps and Lofts

- Most solid geometry is created via sweeping and lofting operations
- Sweeps and lofts are intuitive processes by which to construct objects.
- Sweeps and loft model definitions
  - are constructed internally in the system through use of Euler operators.
  - are constructed externally in system through the use of parent geometry

Sweeping processes:

- Extrusions (translational sweeps)
  - Volume defined by sweeping specified parent geometry through a direction vector.
  - Some software permit scaling of the cross-sectional parent geometry may be applied during the sweep to produce a tapering of the object (draft)

Sweeping processes:

- Solids of Revolution (rotational sweeps)
  - Volume defined by the rotational sweep of specified parent geometry through a defined angle, about a defined axis.

Translational and Rotational Sweeps

Sweeping processes:

- General Sweeps
  - Volume defined by sweeping parent geometry of a section profile (closed) through a path defined by a curve of arbitrary shape

Shape curve and sweep path

Resultant solid from operation
Sweeps: Requirements

- The sweep profile may consist of multiple segments, but must be continuous (no gaps).
- The sweep profile must form a closed loop in order to create solid geometry.
- The sweep profile must existing within a single plane.
- The sweep path must continuous.

Sweeps: Concerns

- Care must be used in defining sweep geometry such that it does not self-intersect.
- If the sweep path includes arcs or splines of a small radius as compared to the profile being sweep, self-intersection may occur.
- In general keep sweep profiles as simple as possible.

Self-Intersecting Sweep

When viewed in wireframe display, the self-intersection is very apparent.

Lofts:

- Defined by 2 or more cross-section curves (profiles or section curves)
- Spline curves fitted to corresponding points on each profile to define the boundaries of the loft's faces

Lofts

Spline curves constructed from profiles

Final lofted geometry
Lofts:
- Orientation of profiles may be limited
  - may restrict profiles to parallel planes
- Number of curve segments per profile may be limited
  - may require the number of curve segments per profile to be the same

Reducing Solid Modeling Errors
- Try to construct models in the same sequence the analogous real object would be produced
- Avoid trimming surfaces/features
  - Rework features rather than covering up or trimming off to fill-in voids
  - Fix the modeling approach, rather than creating tiny features

Reducing Solid Modeling Errors
- Avoid large and small geometries in close proximity
- Avoid small corner angles, small features, small angles
- Minimize the occurrence of narrow surfaces
- Be aware of potential for non-manifold constructions

Editing a Solid Model
- Use the reordering of object creation sequence to avert failures
- Avoid offsetting surfaces/solids to fix intersection errors

Editing a Solid
- Editing which alters only geometry* maintains validity
  *Moving edges, faces
- Editing which changes topology* may violate validity checks, causing errors
  *Any edit which changes the number of vertices and/or edges in a face

Example of a geometric edit
(no change in topology)
Example of a topological edit
(change in the number of edges, and faces)

Editing a Solid
• solid extrude, sweep, and loft operations may be edited by changing, replacing, adding or removing a shape profile or in the case of sweeps, making changes in the sweep path.

Editing an Extrusion Feature
• Change profile
  – Redefine the profile shape
• Change direction
  – Modify the direction in which the feature is created
• Change distance
  – Alter the extent distance or the termination technique for the feature (e.g. blind to geometric termination)

Changing the Extrusion Profile

Change the Extrusion Direction

Change the Extrusion Distance
Editing a Swept Feature

- Change profile
  - Redefine the profile shape
- Change path
  - Alter the path the sweeps follows
  - Alter the orientation of the sweep profile with respect to the path

Sweep Parent Geometry and Final Solid

Sweep With Changed Profile Shape

Sweep With Changed Profile Orientation with Respect to Path

Editing by Tweaking Operations

- Other operations, which do not affect the number of vertices, edges, and loops, and hence need not obey Euler’s Law may be included.
- These allow the geometry to be “tweaked” by moving these vertices, edges, and loops “small” distances.

Tweaking Operation

Edge of solid translated in direction of arrow