Outline

- Background Introduction to Solid Modeling
- Solid Model Representation Schemes
- Solid Primitives
- Operations on Primitives
- Hands-on session on Autodesk Fusion 360 Solid Modeling Software
Introduction to Solid Models

- A Solid model is a complete, valid and unambiguous geometric representation of physical object.

- Contrary to the surface (or wireframe) model, a Solid Model provides topological information in addition to the geometrical information.
Why Solid Modeling?

- Solid modeling provides a solution to the weakness of wireframe and surface modelling, namely
  - Ambiguity and incompleteness in the geometric description in Wireframe/surface modeling
  - Lack of topological information in wireframe/surface modeling
  - Complexity of the modeling process
- Precise models of parts and assemblies are created using solid modeling software
- 3D solid modeling package allows users to develop full solid models in a simulated environment for both design and analysis
Solid Models

- Analysis automation and integration is possible only with solid models: has properties such as weight, moment of inertia, mass.
- Solid model consist of geometric and topological data
- Solid Modeling is used by students, designers, engineers, and other professionals to produce simple and complex parts, assemblies, and drawings.
- This approach saves time, effort, and money that would otherwise be spent prototyping the design.
Some Solid Model Representation Schemes

- Boundary Representation (B-Rep)
- Constructive Solid Geometry (CSG)
- Sweeping
- Primitive Instancing

3 most popular schemes: B-rep, CSG, Sweeping
Characteristics of Solid Model Representation

What makes a good solid representation?

- Accurate
- Concise
- Easy acquisition
- Guaranteed validity
- Efficient boolean operations
- Efficient display
Constructive Solid Geometry (CSG)

- Objects are represented as a combination of simpler solid objects *(primitives)*.
- The primitives are such as cube, cylinder, cone, torus, sphere, etc.
- Copies or “instances” of these primitive shapes are created and positioned.
- A complete solid model is constructed by combining these “instances” using set specific, logic operations *(Boolean Operators)*.
Solid Primitives

- Block
- Cylinder
- Wedge
- Sphere
Solid Primitives

TORUS

CONE

\[ R, R_o, R_i, H, X, Y, Z \]
CSG – Boolean Operations

- Each primitive solid is assumed to be a set of points, a boolean operation is performed on point sets and the result is a solid model.
- Boolean operation: union, intersection and difference
- The relative location and orientation of the two primitives have to be defined before the boolean operation can be performed.
- Boolean operation can be applied to two solids other than the primitives.
Boolean Operations: Union

- The Boolean Operation “Union” represents the sum of all points in each of two defined sets - (logical “OR”). Also referred to as Add, Combine, Join, Merge.

3 Dimensional

UNION: BLOCK $\cup$ CYLINDER
Boolean Operations - Difference

- The Boolean Operator "Difference" represents the points in a source set minus the points common to a second set - (logical "NOT")
- Set must share common volume,
- Also referred to as subtraction, remove, cut
Boolean Operations: Intersection

- The Intersection Operator refers to those points common to each of two defined sets (logical “AND”)
- Set must share common volume
- Also referred to as common, conjoin

INTERSECTION:
BLOCK \( \cap \) CYLINDER
\( A \cap B \)
Components - PARTS

A Solid model has some basic components:

- The first, and most basic element of a solid model is a Part.
- Parts consist of primitive geometry and features such as extrudes, revolutions, lofts, sweeps, etc.
- Parts constitute the building blocks for all of the models created
Components - Assemblies

- Assemblies are collections of parts which are assembled in a particular fashion using mates (constraints).

- Any complex model will usually consist of one, or many assemblies.
Some Solid Modeling Software

- SolidWorks
- Fusion 360
- BowlerStudio (Developed at WPI)
- 3D Studio Max
- Maya
- Blender
- Etc