Introduction to Solid Modeling

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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

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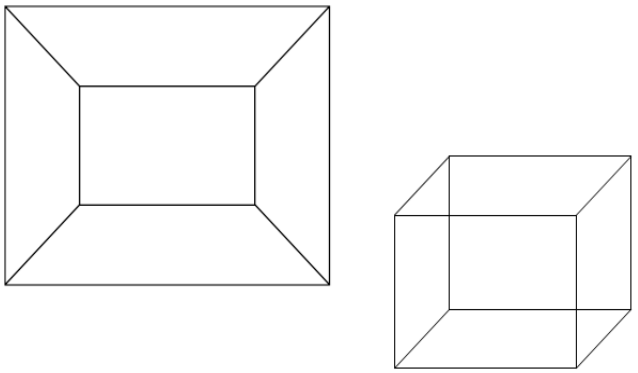
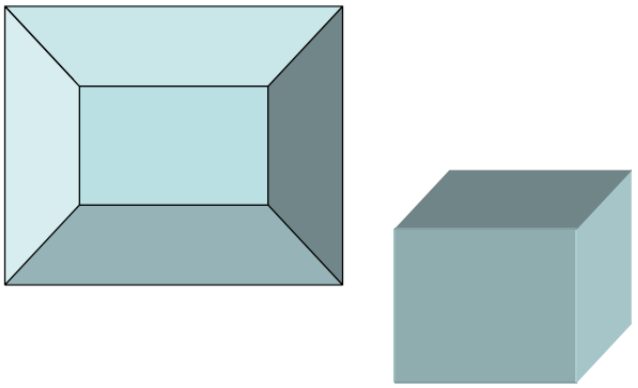
Introduction to Solid Models

- 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.



Wireframe Model



Solid Model

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

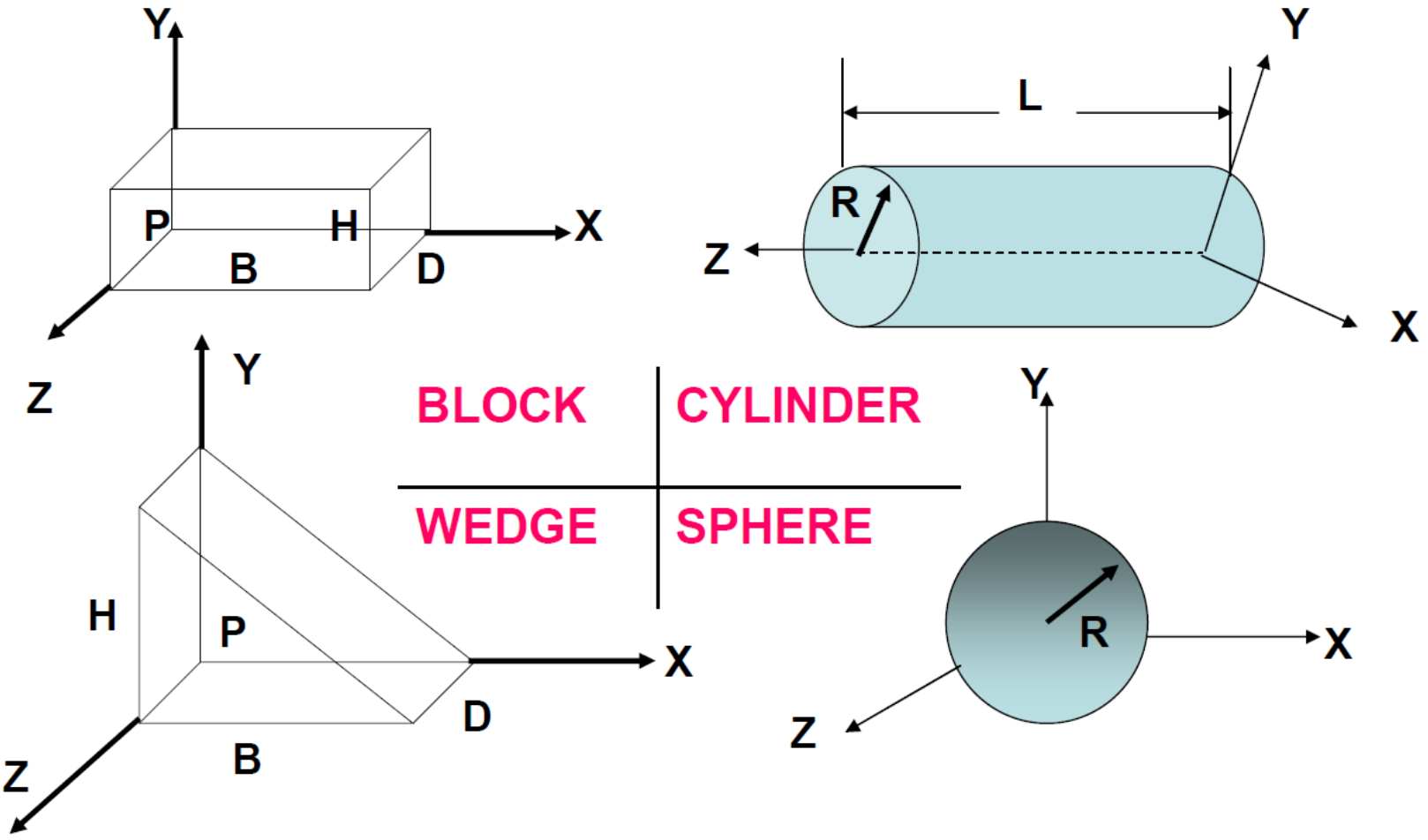
Characteristics of Solid Model Representation

- What makes a good solid representation?
  - Accurate
  - Concise
  - Easy acquisition
  - Guaranteed validity
  - Efficient boolean operations
  - Efficient display

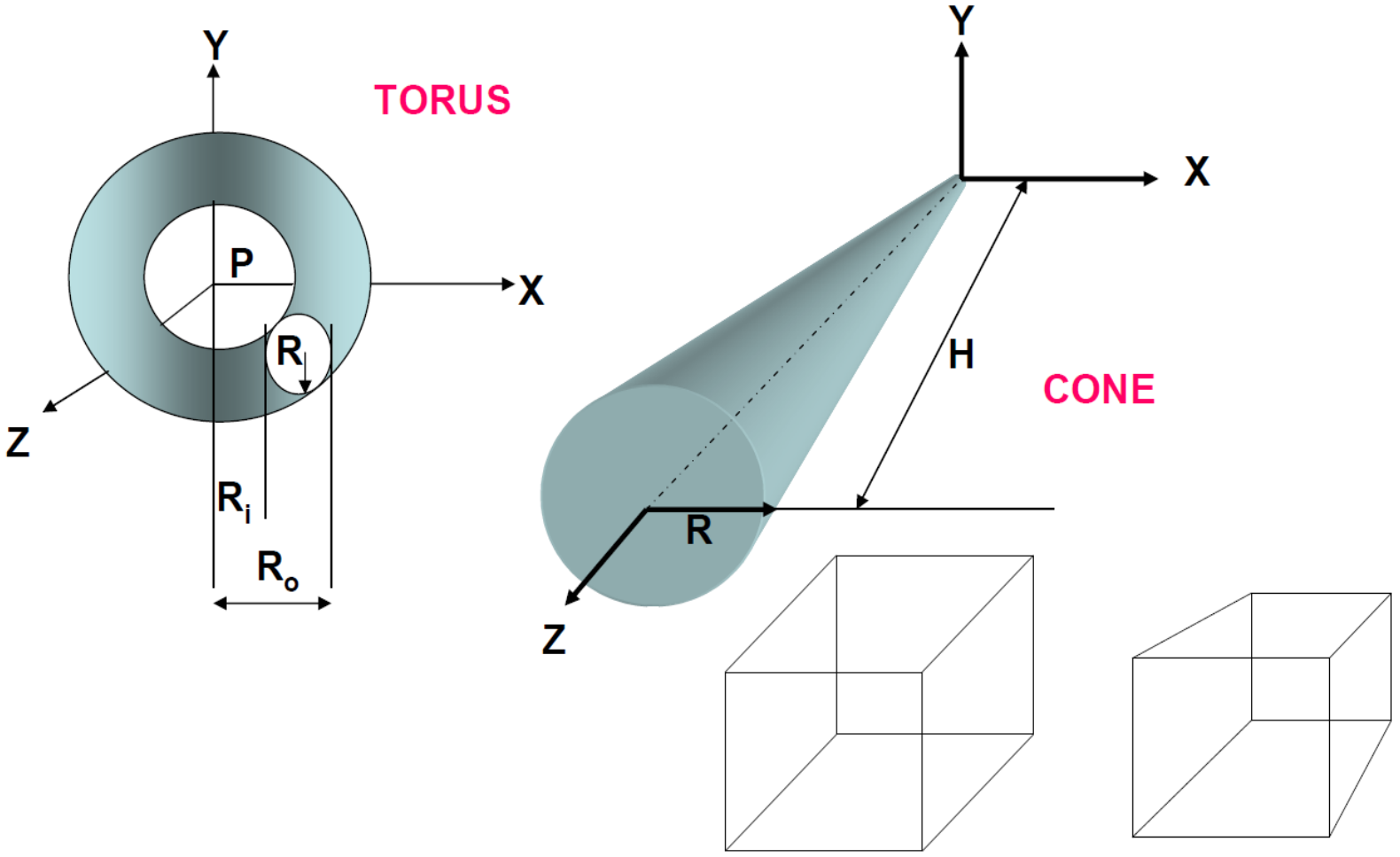
Constructive Solid Geometry (CSG)

- 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



Solid Primitives

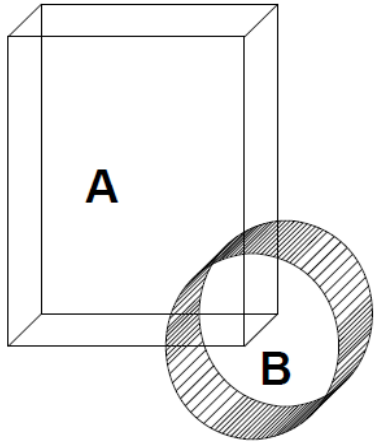


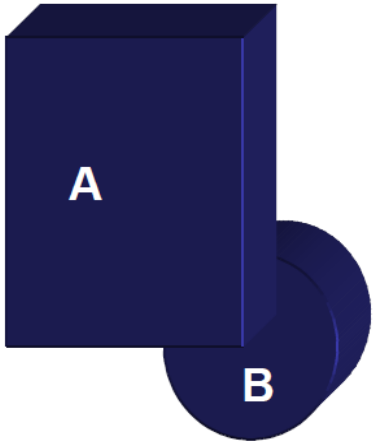
CSG – Boolean Operations

- 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



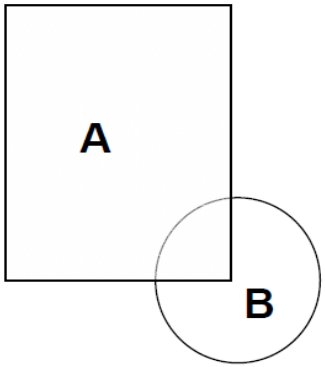


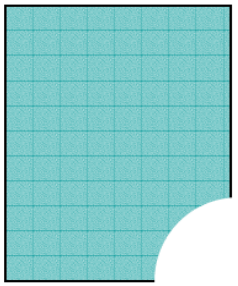
3 Dimensional

UNION: BLOCK ∪ CYLINDER $A \cup B$

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





A - B

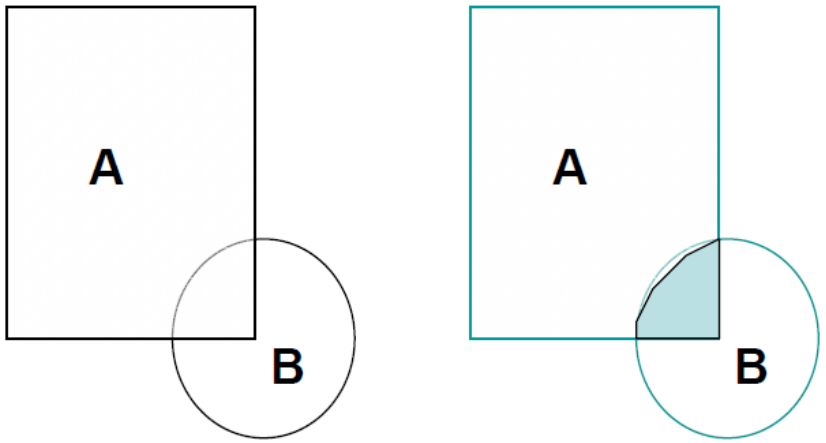
B - A

DIFFERENCE:

BLOCK - CYLINDER

Boolean Operations: Intersection

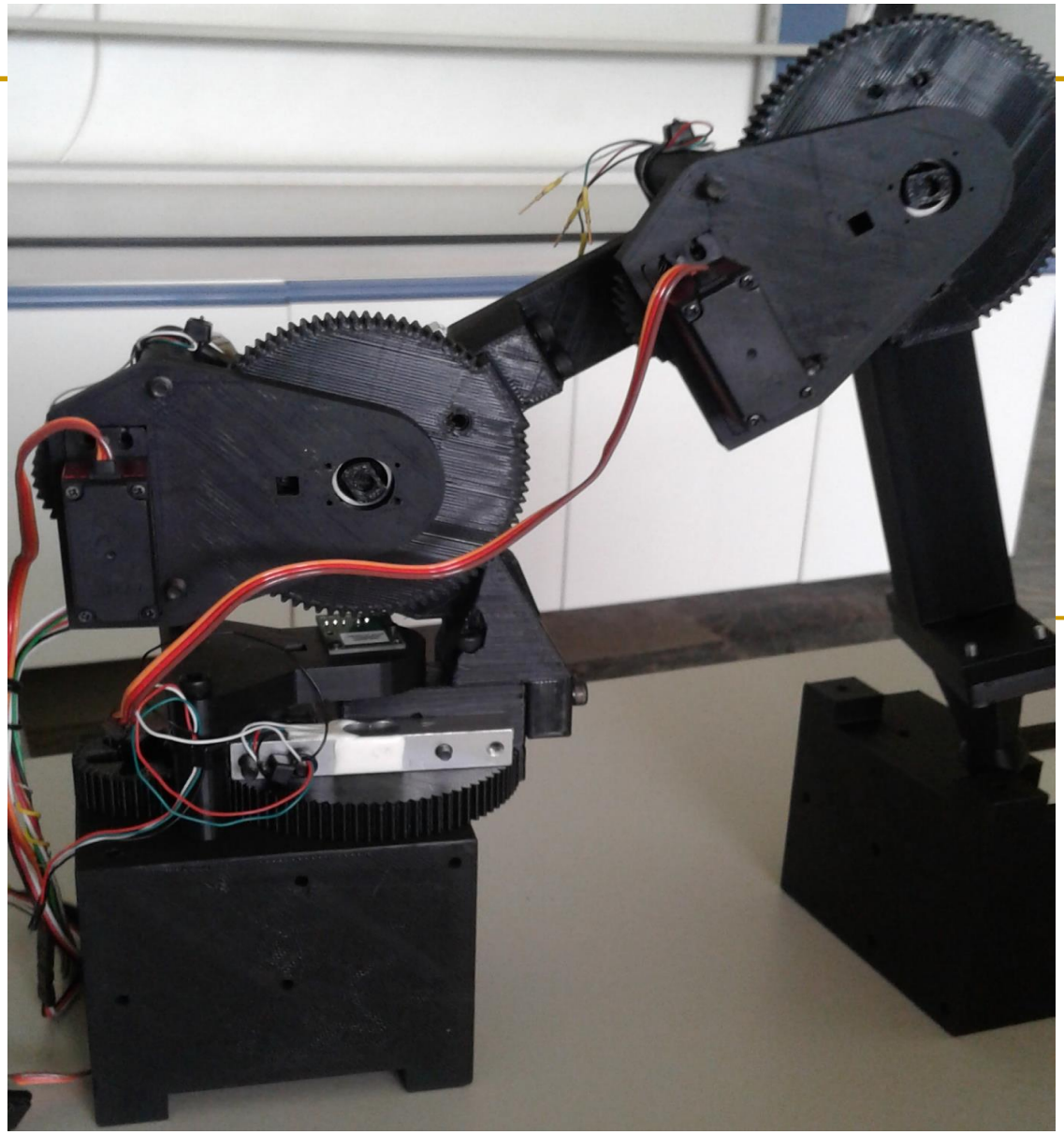
- The Intersection Operator refers tothose points common to each of two defined sets (logical “AND”)
- Set must share common volume
- Also referred to as common, conjoin



INTERSECTION:

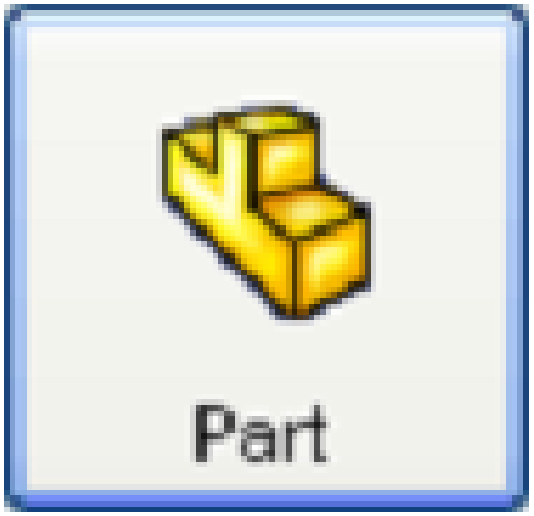
BLOCK ∩ CYLINDER

A ∩ 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