

The ANSWERS Software Service Features for importing CAD geometries in MCBEND

Adam Bird

Contents

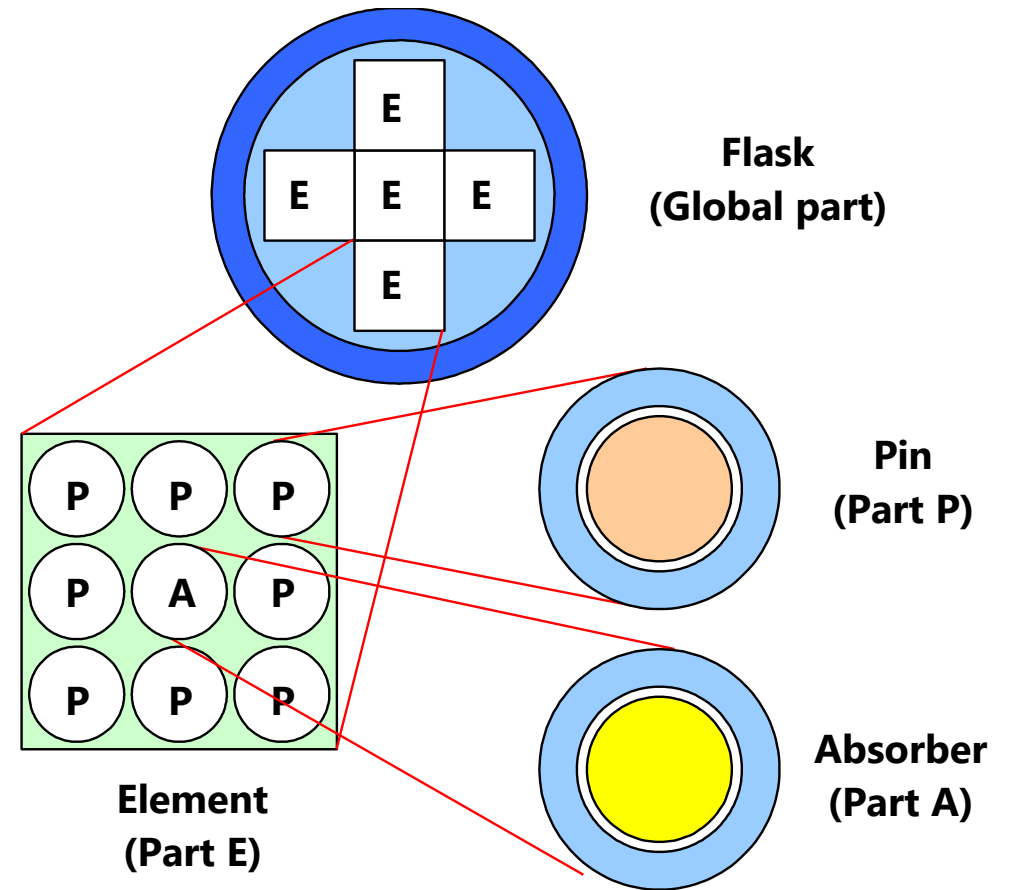
- 1. MCBEND Geometry Definition.**
 - 2. Tetrahedral Mesh Import.**
 - 3. Triangular Polygon Surface Import.**
 - 4. IGES file import.**
 - 5. A discussion of one of the problems associated with Importing CAD models into Monte-Carlo codes using a cylinder as an example.**
-

The ANSWERS Software Service

- ANSWERS® Software Service based in Dorset – which develops and maintains the UK's radiation transport codes.
- Support operation of existing UK reactors, Support to design and licensing of new reactors, Extensive user base in UK and abroad.
- Precursor organizations include:
 - Wood
 - National Nuclear Corporation (NNC)
 - UK Atomic Energy Agency (UKAEA) and AMEC
- Involvement in a range of R&D activities:
 - UK National R&D Programme
 - Collaborations with universities
 - Development of advanced reactor technologies
 - European R&D projects

Geometry Definition in MCBEND

- In common with many Monte-Carlo codes early geometry specification was more concerned with the needs of the solver and computing capabilities of the time than that of the user.
- Various incarnations have improved the geometry definition to make it much easier to generate complex models in concise ways.
- The main geometry definition is a body based hierarchical Combinatorial Solid Geometry (CSG) system. In MCBEND we call it 'Fractal Geometry' (FG).



Geometry Definition in MCBEND

- The following features are available within FG, these can be mixed and matched in the same model:
 - Wide range of geometries that use Delta or Woodcock tracking, Referred to as 'Holes'.
 - Voxel geometry type, available as surface tracking or Hole. For example, CT data.
 - Tetrahedral Mesh geometry type, available as surface tracking or Hole.
 - Triangular polygon surface CSG body type. For example STL or OBJ file types.
 - IGES geometry type. For example IGES CAD files.
- The imported geometry types are not translated or converted to FG. They are all implemented with dedicated Delta tracking and / or Surface tracking code.

Tetrahedral Mesh Geometry Type

The format of the file is as follows:

```
1128683573
Version number: 5.6S
162703 21605 0 0 0 6 0

4.5837421 38.681 -1.295635
4.574881 38.6904 2.92143
-2.92019 81.8154 4.5629301

23195 23269 4835 4834
1423 23600 1009 8359

8276 MATERIAL_2_RUNCOOL
2421 2422 2423 2424 ...
2431 2435 2436 2437 ...
```

Mesh type (Unused)

Version number: 5.6S (Unused)

Vertices Tetrahedra Prisms Hexes Pyramids
Bodies Surfaces

Only Vertices, Tetrahedra and Bodies are used.

List of vertices.

3 numbers per line. (In this case 162703
lines)

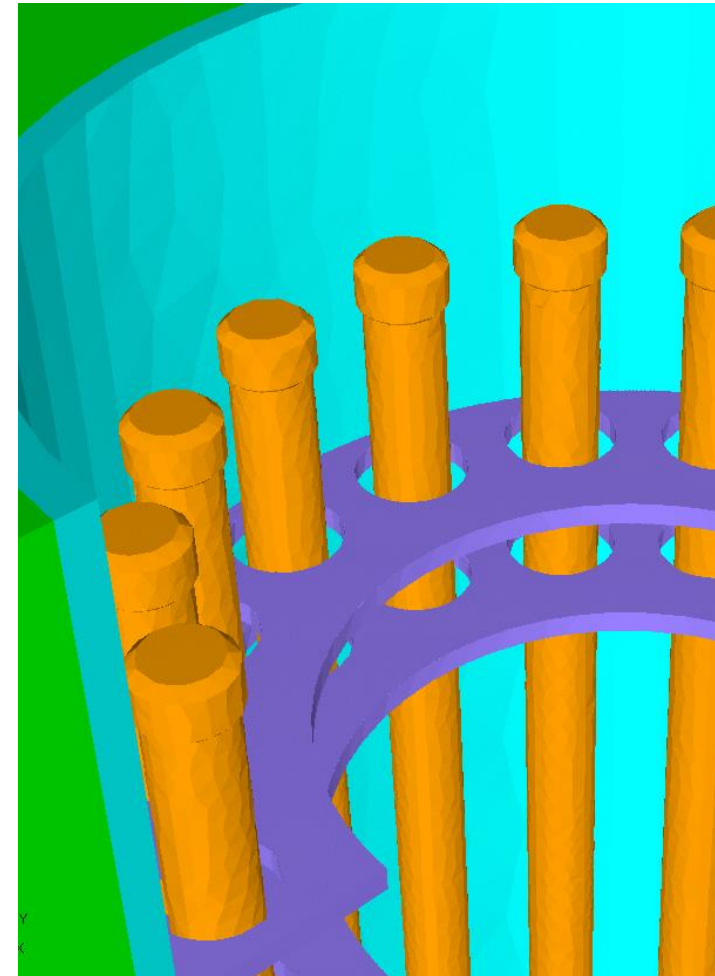
Tetrahedra definitions.

4 vertices per line. (In this case 21605 lines)

Body definitions. (In this case 6 defined)

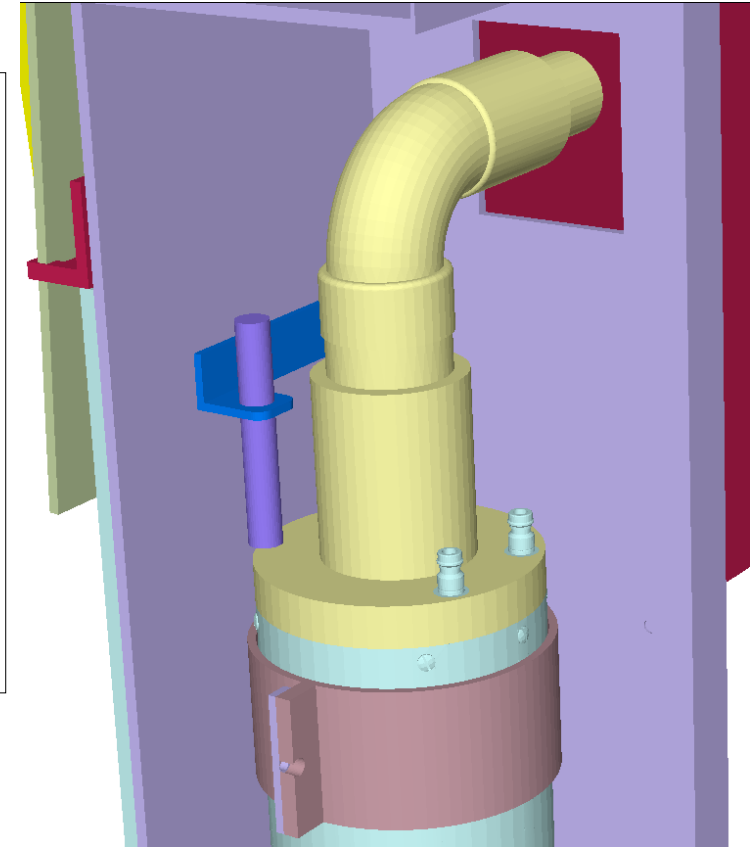
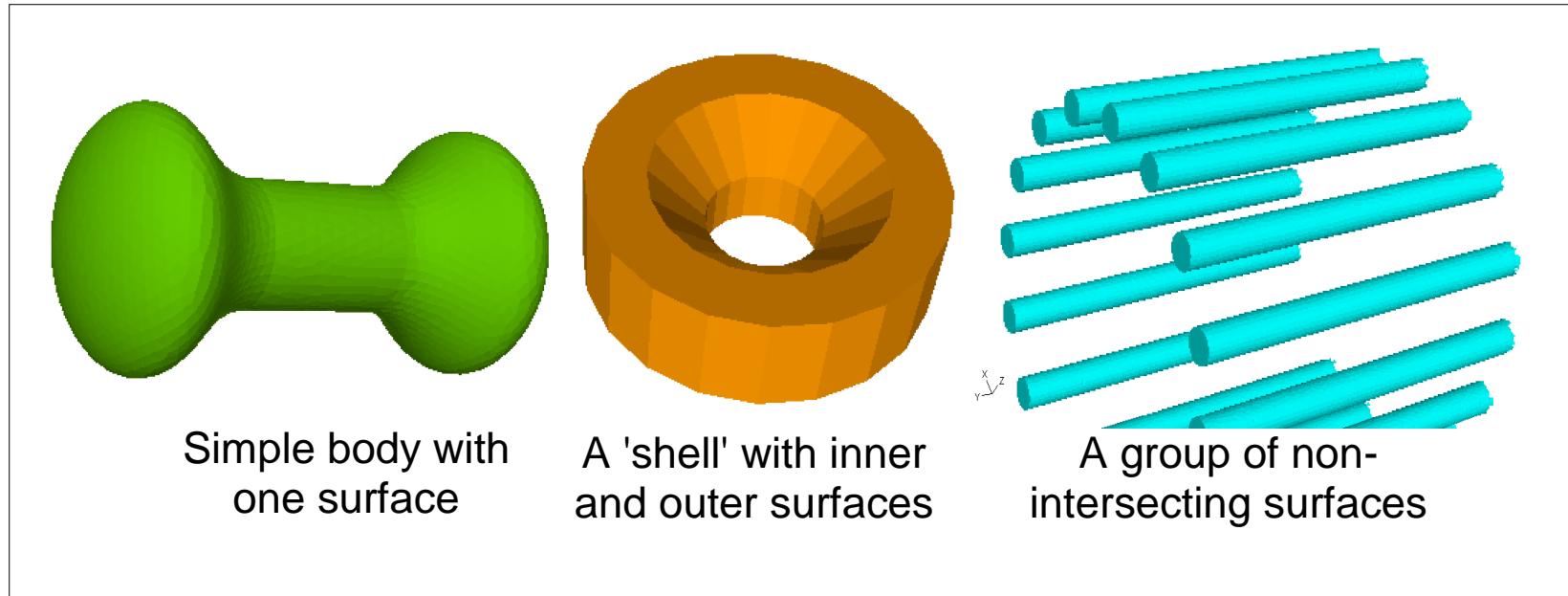
Number of tetrahedra, Body Name

List of tetrahedral. (10 per line)



Triangular Polygon Surface CSG body 'POLY Body'

- An FG body defined from a set of triangular facets.



- A POLY body has a set of numbered nodes defined by their coordinates and facets defined by triplets of node numbers.

The Poly Body

- The Poly Body is implemented as an FG body. It can be defined as:

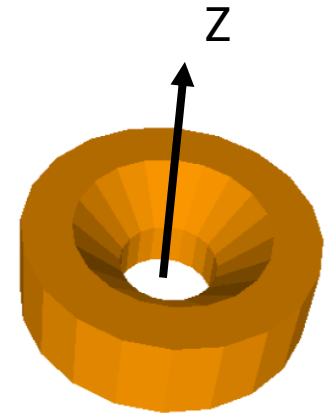
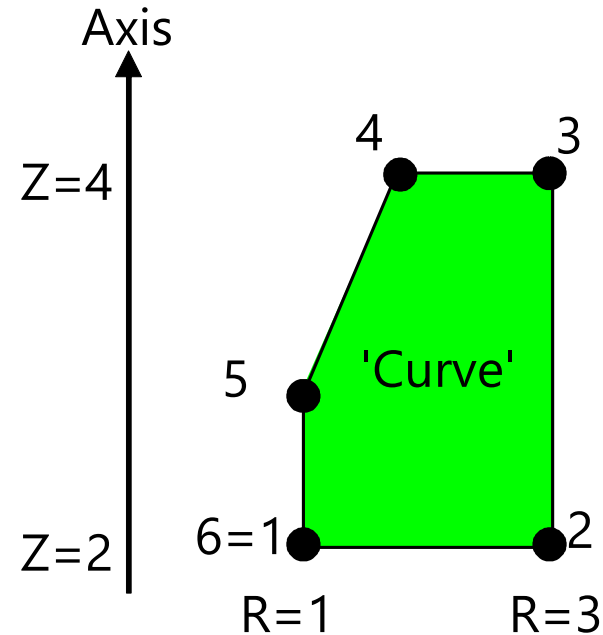
- A list of vertices and triangles.

- A rotated shape 'CURVE' keyword.

- An extruded shape 'EXTRUDE' keyword

- A list of vertices imported from a file

- An STL formatted or binary file.



- A utility in VisualWorkshop (Visualisation and run submission tool for ANSWERS codes) will 'translate' an OBJ file into a set of POLY bodies for inclusion in MCBEND.

Initial Graphics Exchange Specification (IGES) File Import

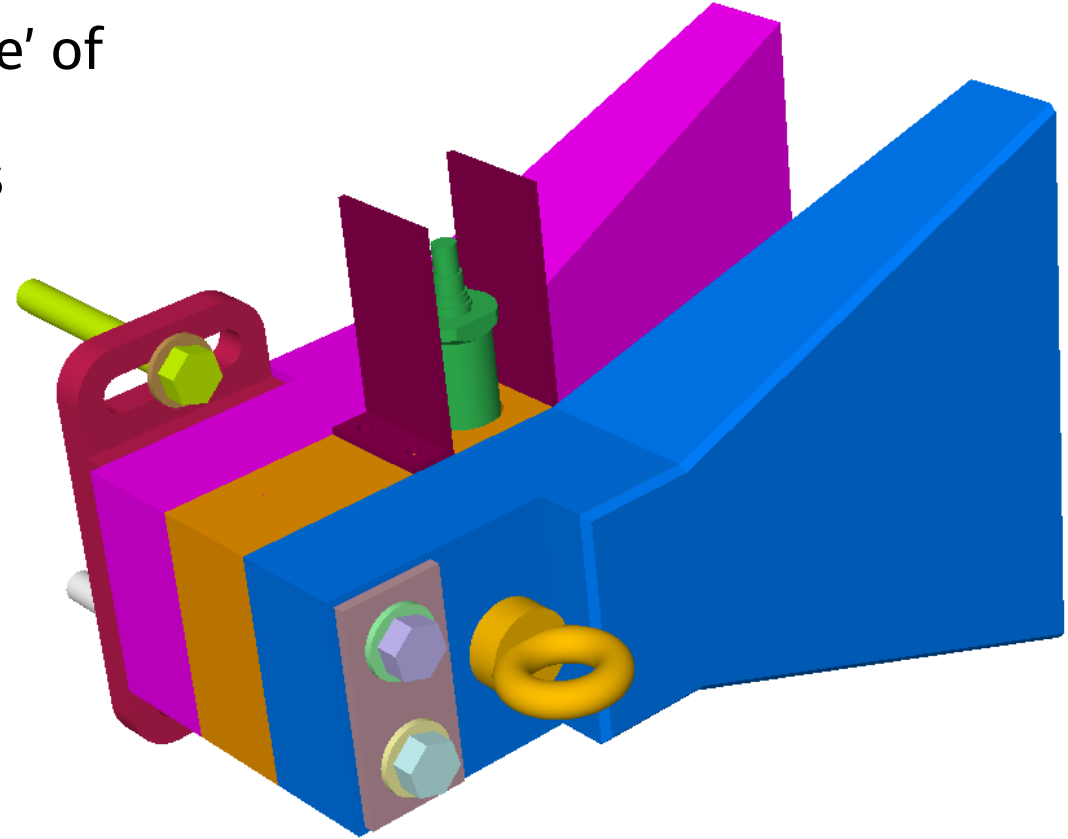
▪ Features:

- The IGES file may contain a single object or an entire model.
- An IGES geometry is an exact representation of the model with no approximations.
- Many of the entity types can be converted to simple bodies or Bezier Patch representation to increase performance.
- In addition to specifying a material it is possible to put a Hole in an object within the IGES geometry.
- It is possible to select individual objects to include or exclude from an IGES file.

Initial Graphics Exchange Specification (IGES) File Import

▪ Drawbacks:

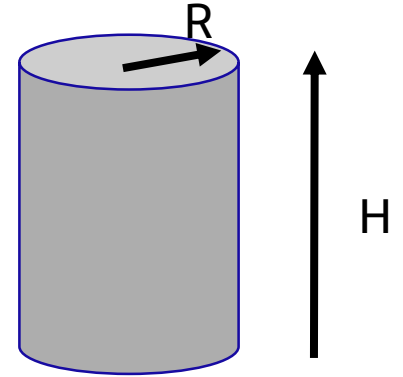
- The development has targeted the 'flavor' or 'style' of IGES exported by the CAD software SolidWorks. Experience has shown that importing of IGES files from other sources can be unreliable.
- It runs approximately 2 – 40 times slower than an equivalent FG model.



Consideration of CAD issues from the perspective of a Cylinder

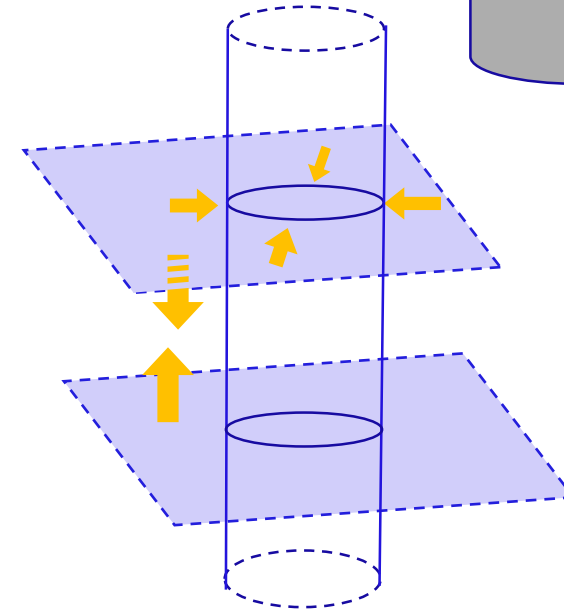
- A user may think of a cylinder as:

- Having a **height** and **radius**
- Being **a)** Standing up or **b)** Lying down or **c)** Some other orientation



- Monte-Carlo codes like to think of a cylinder as:

- A volume of space delimited by surfaces.
- Inside a cylindrical surface
- And above a plane surface (the bottom)
- And below a plane surface (the top)



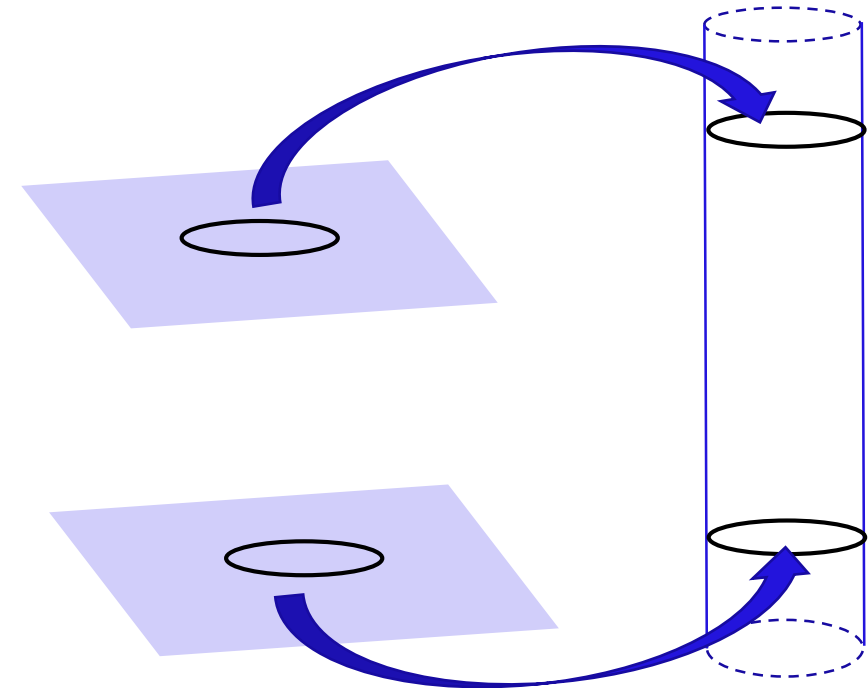
- If your CAD software thinks of a cylinder in these terms then we are happy!

Consideration of CAD issues from the perspective of a Cylinder

- **CAD software designers need to consider many possible shapes.**
- It is inefficient from a development and maintenance perspective to have special code for each shape.
 - Even simple shapes may be defined in terms of quite complex mathematics.
 - It is computationally difficult and expensive to process the more complex mathematics in the physics solver.
 - It can be difficult to 'back out' the simple shape that was originally specified.

Consideration of CAD issues from the perspective of a Cylinder

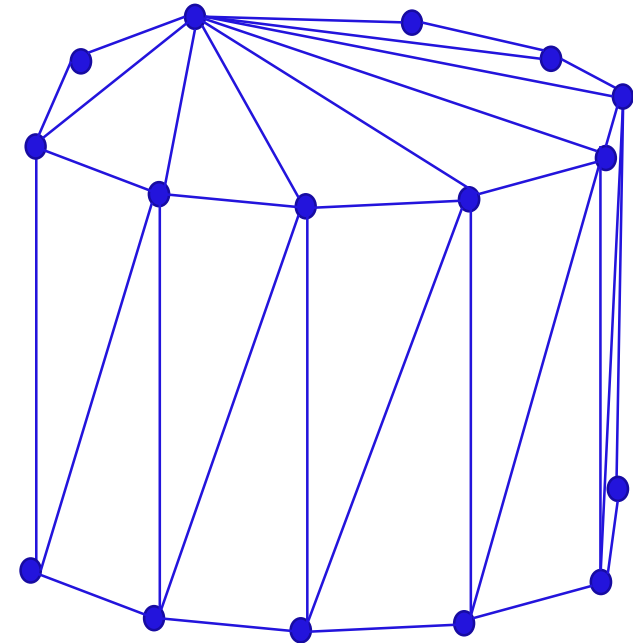
- CAD software may think of a cylinder as an entity containing 8 objects :
 - 2 plane surfaces
 - A general quadric surface in the degenerate form of a cylinder
 - 4 parabolic clipping lines in the degenerate form of circles
 - An object to describe the relationship of the above objects in the entity



It is not necessarily obvious that it is a cylinder.

Consideration of CAD issues from the perspective of a Cylinder

- If your CAD software uses or generates meshes.
 - You need to consider the loss of accuracy when curved surfaces are represented by meshes.
 - Large number of meshes cause performance and storage considerations.



Thank You

Jacobs

Challenging today.
Reinventing tomorrow.



Copyright Notice

Important

The material in this presentation has been prepared by Jacobs®.

©2020 Jacobs Engineering Group Inc. All rights reserved. This presentation is protected by U.S. and International copyright laws. Reproduction and redistribution without written permission is prohibited. Jacobs, the Jacobs logo, and all other Jacobs trademarks are the property of Jacobs Engineering Group Inc.

Jacobs is a trademark of Jacobs Engineering Group Inc.