

Computer Aided Geometric Design

Data Exchange

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(An Institute of National Importance (INI) established by MHRD, Govt. of INDIA)

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Geometric Data Exchange

- Geometric data format in which part geometry information is stored, often varies from one CAD/CAM system to another.
- Geometric data exchange refers to conversion from one geometric data format to another.



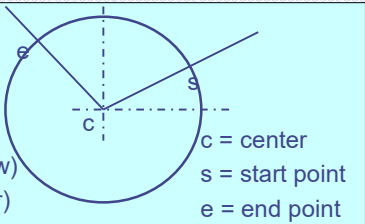
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Geometric Data Exchange

Example:
How do you store a circular arc ?

r = radius
a = start angle
b = end angle
d = direction (cw/ccw)
t = arc (major/minor)



c = center
s = start point
e = end point



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Geometric Data Exchange

The Need

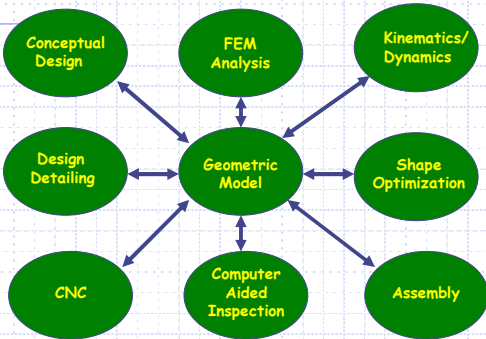
- Heterogeneous expertise
- Use of application specific packages
- Migration from one system to another
- Data exchange with collaborators / customers / suppliers



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Integration of Design & Manufacturing





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Geometric Data Formats

Different Types of Format

- Native format
- Neutral format
- Binary format
- ASCII format



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Geometric Data Formats: Contents

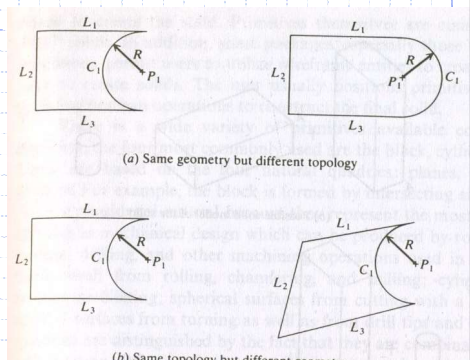
- ◆ Shape data
 - Geometry
 - Topology
 - Form features (Hole, flange, chamfer etc.)
 - Attributes (font, color, layer etc.)
 - Annotations (Dimensions, leader, notes etc.)
- ◆ Non-shape data
 - Graphics data
 - Shaded images
 - Global data (measuring unit, resolution of data storage etc.)
- ◆ Design data
 - CAE analysis information
 - Mass properties
 - Finite element mesh data
- ◆ Manufacturing Information
 - Toolings
 - NC tool paths
 - Process planning
 - Tool design
 - Bill of materials



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Topology and geometry



(a) Same geometry but different topology

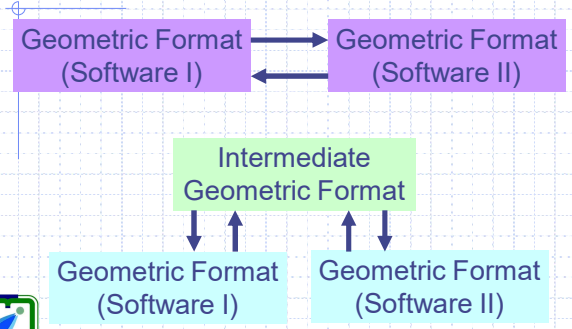
(b) Same topology but different geometry



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Geometric Data Exchange

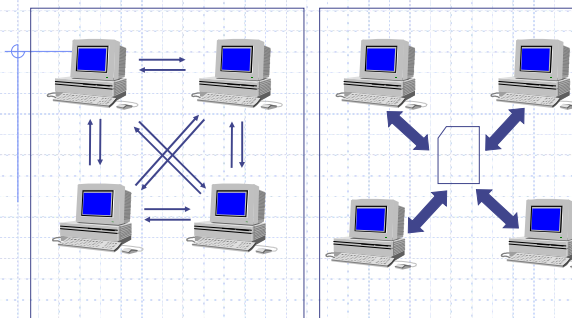




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Efficiency of a Neutral Format for Data Exchange



... By Direct Translators

... By Neutral Format



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For n systems, Number of translators required

- Direct translators

$$N = 2 \binom{n}{2} = 2 \frac{n!}{(2)!(n-2)!} = n(n-1)$$

- Indirect translators

$$N = 2n$$

- ◆ Direct translators run more quickly
- ◆ File size is less in direct translations



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Geometric Data Formats : IGES

- ◆ Collection of geometric and non geometric entities.
- ◆ Stands for Initial Graphics Exchange Specification.
- ◆ Topology and geometry of given object is stored separately.
- ◆ Both binary and ASCII formats are permissible
- ◆ Divided into 5 sections:
 - Start: indicated by letter S on the first line of the file.
 - Global: indicated by letter G. It shows the properties of the file (file name, system that creates the file, units and precision). Normally comprising of 5 lines (G1 to G5)
 - Directory Entry: shown by letter D. Show all the non-geometry properties (color, line type, transformation matrices)
 - Parameter Data: shown by letter P. Show all the geometrical properties of the entities.
 - Terminate: ends of the file and shown by letter T.



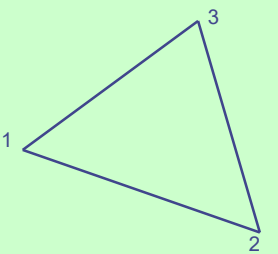
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Geometric Data Formats : STL

- ◆ Developed for rapid prototyping applications.
- ◆ A solid object is stored in terms of its boundary consisting of only triangles and their outward normal.

$$\begin{pmatrix} x_1, y_1, z_1 \\ x_2, y_2, z_2 \\ x_3, y_3, z_3 \\ n_x, n_y, n_z \end{pmatrix}$$





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Geometric Data Formats : ACIS

- ◆ *Alan, Charles, Ian's System*
- ◆ *Divided into 4 sections*
 - **Start:** start with array of number (600 0 1 0)
 - **File Data:** information on the software generate the file, date precision etc.
 - **Entity Data:** topology and geometry data are stored here. Every line starts with structure names and ends with #
 - **End:** remarks the end of the file by 'End-of-ACIS-data' statement.



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Geometric Data Formats : DXF

- ◆ Developed by Autodesk for geometric data transfer using ASCII definitions.
- ◆ A simple and popular neutral format for data exchange.
- ◆ Can be considered 'pseudo' standard due to popularity of AutoCAD.
- ◆ Divided into 4 section
 - **Header:** information on the drawing.
 - **Tables:** properties of non-geometrical entities such as line type, layer, dimensional format etc.
 - **Blocks:** information on blocks.
 - **Entities:** geometrical properties of the entities in the drawing.

Every section begins with the name of the section in capital letters and end with 'ENDSEC'.



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Geometric Data Formats

- ◆ VDA
 - ◆ It is German standard for CAD data exchange.
 - ◆ VDA-FS (DIN 66301) is a standard for modelling surfaces.
 - ◆ VDA-IS - A German subset of IGES for the auto industry.



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Geometric Data Formats

- ◆ VRML
 - ◆ It stands for Virtual Reality Modeling Language.
 - ◆ Developed for representing 3D geometries for www applications.
 - ◆ Allows interaction and animation apart from representation.



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Geometric Data Formats

- ◆ SET
 - ◆ It is French Government effort to develop a standard for geometric data exchange.
 - ◆ SET (Standard d'Echange et de Transfert) is made to be more compact than IGES



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Product Modeling

It refers to identifying & modeling of product related information and exchange of the same among various life-cycle activities to facilitate product related decisions to be taken quickly and effectively.



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Product Modeling

- Function
- Specifications & Constraints
- Geometry
- Design History
- Material
- Assembly & Bill of Materials
- Tolerances & Surface Finish
- Process data
- Business Information



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Standards for Product Modeling

What is STEP ?

- Stands for **ST**andard for **E**xchange of **P**roduct data (ISO 10303).
- International effort to develop standards for **computer interpretable representation and exchange of product data**.
- Specified by its application
 - AP201: Drawing
 - AP207: Sheet metal die
 - AP224: Mechanical Product Definition
 - AP238: STEP – NC
- Divided into 2 section
 - Header**: starts with Header; and ends with ENDSEC;. Purpose: propose to show the file type, file name and software used.
 - Data**: Starts with DATA; and ends with ENDSEC;. Comprise of the topological and geometrical data of the objects.



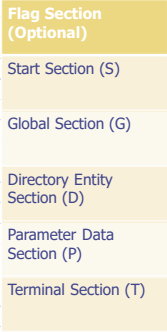
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IGES File structure

- Two different formats are used to represent IGES data:
 - Binary and
 - ASCII.
- The ASCII format, has two types;
 - A fixed, 80-character line length format and
 - A compressed format which was introduced in IGES 3.0; where the directory section and the parameter data section are combined.

The data in the combined sections are in free format, so all unnecessary spaces are removed and the files are reduced to one third of their previous size

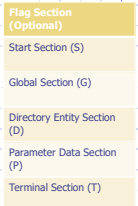


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IGES File structure

- The IGES file is sequential and consists of five or six (for binary or compressed ASCII format) sections:
 - flag, start, global, directory entity, parameter data and terminate.
- IGES file contains
 - Geometric and non geometric data (annotations and structure)
 - Geometric entity
 - Define product shape includes curves, surface and solids
 - Annotations
 - Dimensions, notes, center lines, labels, cross hatchings etc.
 - Structure
 - Views, drawings, attributes (line and text fonts, colors and layers)
 - Properties, sub figures and external cross references, symbols, macros etc.



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IGES Geometric entities

Entity Number	Entity description	Entity Number	Entity description
100	Circular arc	126	Rational B-spline curve
102	Composite curve	128	Rational B-spline surface
104	Conic arc	130	Offset curve
106	Copious data	132	Connect point
108	Plane	136	Finite element
110	Line	138	Nodal display and rotation
112	Parametric spline curve	140	Offset surface
114	Parametric spline surface	142	Curve on a parametric surface
116	Point	144	Trimmed parametric surface
118	Ruled surface	146	Nodal results
120	Surface of revolution	148	Element results
122	Tabulated cylinder	150	Block
124	Transformation matrix	152	Right angular wedge
125	Flash	154	Right circular cylinder



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IGES Annotation entities

Entity Number	Entity description	Entity Number	Entity description
202	Angular dimension	216	Linear dimension
206	Diameter dimension	218	Ordinate dimension
208	Flag note	220	Point dimension
210	General label	222	Radius dimension
212	General label	228	General symbol
214	Leader (arrow)	230	Sectional area



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IGES Structure entities

Entity Number	Entity description	Entity Number	Entity description
302	Associativity definition	406	Property
304	Line font definition	408	Singular subfigure instance
306	Macro definition	410	View
308	Subfigure definition	412	Rect. Array subfig. instance
310	Text font definition	414	Circular array subfig. Instance
312	Text display template	416	External reference
314	Colour definition	418	Nodal load/constraint
320	Network subfigure definition	420	Network subfigure instance
402	Associativity instance	600-699	Macro instance (user defined)
404	drawing	10000-99999	Macro instance (user defined)



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Format of the start section

- The **start section** is used to provide a human-readable prolog to the file. This prolog is not formatted and should be written using the ASCII characters.
- The **global section** contains the information which describes the preprocessor used to create the IGES file.
- It also contains the information needed by the postprocessor at the other end to handle the IGES file.
- The parameters in the global section are in a free format.
- Two consecutive parameters are separated by the parameter delimiter character.
- The global parameters end with the record delimiter character.

1	72	73	80
This section is a human-readable prologue to the file.		S0000001	
It can contain an arbitrary number of lines		S0000002	
.		S0000003	
.		.	
.		.	
Using ASCII characters in columns 1-72		S000000N	



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Format of the directory entry section

- The directory entry for each entity is fixed in size and contains 20 fields of 8 characters each.
- Occupies 2 consecutive 80-character lines.
- The data in each field is right-justified.

1	8	9	16	17	24	25	32	33	40	41	48	49	56	57	64	65	72	73	80
(1) Entity type no. #	(2) Parameter data #	(3) Structure #	(4) Line font pattern #	(5) Level #	(6) Level 0, #	(7) Transformation matrix 0, #	(8) Label display assoc. 0, #	(9) Status number #	(10) Sequence number D #	(11) Entity type number #	(12) Line weight number #	(13) Colour number #	(14) Parameter line count #	(15) Form number #	(16) Reserved	(17) Reserved	(18) Entity label	(19) Entity subscript number #	(20) Sequence number D # + 1

Nomenclature:
(n) - Field number n
- Integer
- Pointer
- Integer or pointer (pointer has negative sign)
0, - Zero or pointer



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Format of the parameter data section

- At least one line for each entity. The first parameter in a parameter data entry is always the entity type number.
- Parameter delimiter character is used to separate two consecutive parameters.
- The relationship between an entity's records in the both sections is established through bidirectional pointers.

11	64	66	72	73	80
Entity type number followed by parameter delimiter followed by parameters separated by parameters delimiters	DE	Pointer		P0000001	
Parameters separated by parameters delimiters followed by record delimiter	DE	Pointer		P0000002	
.	.	.	.	.	.
.	.	.	.	.	.

Note: The DE pointer is the sequence number of the first directory entry line for this entity



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Format of the terminate section

- The terminate section contains the total number of lines in each of the previous sections.
- In the terminate section there is only one line, which is divided into 10 fields of 8 column each.
- The first 4 fields contain the section-identification character followed by the last sequence number used in the start, global, directory and parameter data section respectively.

1	8	9	16	17	24	25	32	33	40	41	48	49	56	57	64	65	72	73	80
S0000020	G0000003	D0000500	P0000261	Not Used															T0000001



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