Government College of Engineering and Research
Avasari, Pune

SOLID MODELING AND DRAFTING

Mr. Sanjay D. Patil
Assistant Professor,
Automobile Department
sanjaypatil365@gmail.com

Course Outcomes

On completion of the course, learner will be able to,

- UNDERSTAND basic concepts of CAD system, need and scope in Product Lifecycle Management
- UTILIZE knowledge of curves and surfacing features and methods to create complex solid geometry
- CONSTRUCT solid models, assemblies using various modeling techniques & PERFORM mass property analysis, including creating and using a coordinate system
- APPLY geometric transformations to simple 2D geometries
- USE CAD model data for various CAD based engineering applications viz. production drawings, 3D printing, FEA, CFD, MBD, CAE, CAM, etc.
- USE PMI & MBD approach for communication

Course Introduction and Motivation

- Automobiles are need for everyone in this world. People use this for transportation purposes and several other reasons like trading of goods and services from one place to another.
- In the current highly competitive market, the vehicle development time and cost need to be reduce.
- At the same time, increasing customer demands in terms of safety, comfort and fashion
- In order to develop lighter, more efficient, new vehicle architecture and styling, the new solutions will need to be introduced.
- These days, automotive development is driven by the interaction of virtual design and simulation methods in combination with physical development and testing procedures
- More than a hundred years ago, at the beginning of automotive development, the inventors of new motorized vehicles built up their creations in simple workshops supported by a small group of specialists.

Highlights on Automobile Evolution

1886 – The first car is invented by Austrian Karl Benz power by IC Engine

Bugatti Type 57 SC Atlantic (1937)

1946 GA[illegible] Pobeda one of the first mass-produced cars with ponton [illegible]n

1926 Buga[illegible]e 35

1929 Austin Seven

1954 Plymouth Savoy Station Wagon, one of the first U.S. all-metal station wagons

1959 Morris Mini-Minor

Reference : https://en.wikipedia.org/wiki/History_of_the_automobile

Factors Influence on Automobile Development

Few factors those are influence for vehicle development listed below,

- The growth in individual mobility and industrial revolution
- Specific demands of different customer groups.
- Environmental friendliness and fuel efficiency
- Low weight and low driving resistance
- Vehicle safety and better comfort
- reduction of the costs and development
- Constantly evolving demands, contemporary market
- Requirements of legislative bodies around the world.
- Increased complexity of the vehicles design, function, etc.

To meet vehicle development challenges, fundamental changes has to been applied to both the vehicles design and the processes by which they are developed.

Boundary conditions for the development of New vehicle models in the future

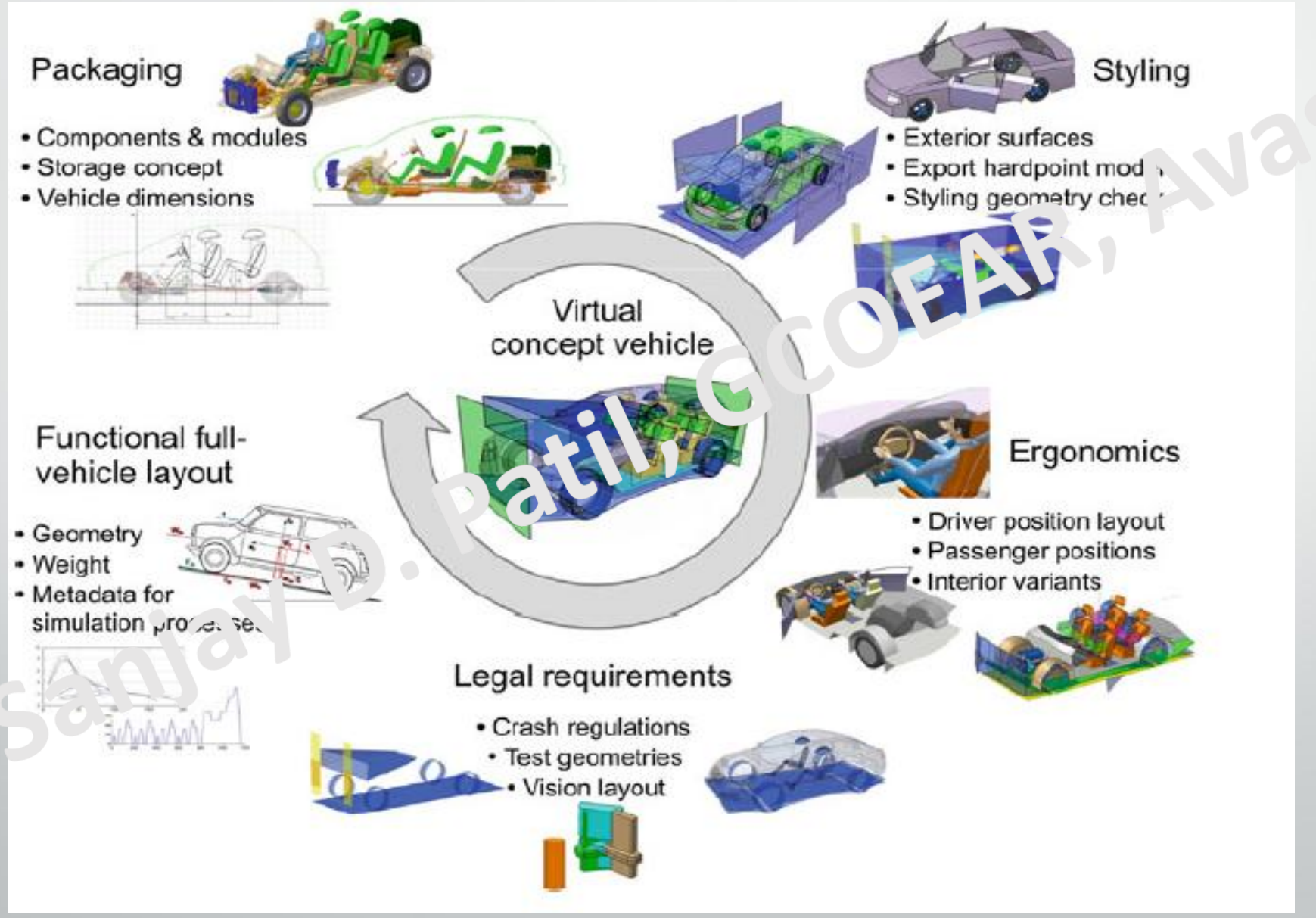
General requirements	Development challenges
• Environmental impact of individual traffic - Air pollution & noise - Increasing traffic densities - Expansion of road networks • Availability of the resource crude oil - Rising fuel & production costs • Traffic safety - Vehicle and pedestrian accidents • Customer demands - Comfort & surplus value functionalities - Fashion & lifestyle	• Continuously stringent exhaust emission regulations • Customer environmental awareness • Alternative propulsion technologies • New energy providing & storage concepts • New vehicle concepts • Worldwide increase of individual mobility • Increasing driving and transportation quantities • Materials and processes using renewable resources • Increasing demands on active & passive vehicle safety • Driving assistance systems • Comfort functionalities • Electrics & electronics

Reference : Mario Hirz , Wilhelm Dietrich, Anton Gfrerrer , Johann Lang Integrated Computer-Aided Design in Automotive Development

Application of CAD in Automotive Development

- Computer Aided Design (CAD) is one of the central disciplines in modern automotive development.
- The efficient CAD models provides the basis for a broad field of concerned engineering processes. (BOM geometrical and functional interactions, production-related information etc.)
- Using the CAD model pre-calculation of vehicle structures, durability and acoustic optimization etc. done by without physical tests
- The provision of CAD data (including geometry, functions, materials, manufacturing and assembling related data) support in the determination of cost-related aspects

Use of CAD data



Source: Mario Hirz , Wilhelm Dietrich, Anton Gfrerrer , Johann Lang Integrated Computer-Aided Design in Automotive Development

Evolution in CAD

Design office circa 1900

Alice in VR at a power wall, 2018

Sources : Dubbel, H., Grote, K.H., Feldhusen, J.: Dubbel-Taschenbuch für denMaschinenbau, 22nd edn. Springer, Berlin (2007)
Newsroom article 26/06/2018
Mr. S. D. Patil, Automobile Department, Government College of Engineering and Research Avasari

THE HISTORY OF CAD

FATHER OF CAD

PRONTO
By: Dr. Patrick Hanratty

PRONTO was the First commercial numerical-control programming system, sparked everything that is CAD. Known as the building blocks of everything CAD

Dr. Patrick Hanratty, An American computer scientist regarded as the "Father of CAD and CAM"

CADD
By: McDonell-Douglas
Used for parts layouts and geometry work, continued to be improved upon and customized for specific uses

Digigraphics
By: Itek
First commercial CAD system, $500000.00 per system, only sold 6 copies

ADAM
By: Patrick Hanratty

Interactive graphics design, drafting and manufacturing system written in Fortran and designed to work on virtually every machine, huge hit that went on to be updated to work on 16 and 32 bit computers, today 80% of CAD programs can be traced back to the roots of ADAM

Unigraphics
By: Siemens NX
High end easy to use software used by many corporations that set a new gold standard for CAD software at this time

Autodesk AutoCAD
First CAD software made for PCs instead of mainframe computers

CADENAS Founded
Founded originally as an engineering firm but realized the potential of the engineering IT age

STEP
Took over from IGES as the new format to use when transferring 3D models from one to another, 1994 was the initial release of STEP that made it an international stand- models, still the r used format

SolidWorks 95
By: Dassault Systemes
Another software that succeeded in ease of use, allowed more engineers than ev take a tage of technology

CATIA
Co ncing Groupw re
B assa Systemes
T ve on all g use rev and ann e CATIA mod with ther ver the internet, quickly llowed by others- Unigraphic's iMAN web author and CoCreate's Openspace Web

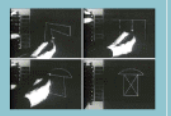
Autodesk 360
Moved to the cloud, others followed

The Future
Focus on Virtual Reality

THE MOUSE

The computer mouse become widely used in the late 70's, its original design was made by Douglas Engelbert who filed for the patent in 1967. The introduction of the mouse changed the way designing worked by making it easier for engineers to navigate a computer and design their parts.

1957 1960 1966 1967 1967 1970 1971 1975 1977 1978 1980 1981 1982 1987 1992 1994 1995 1995 1996 1999 2012 2013 2015 2017



Sketchpad
By: Ivan Sutherland
First to ever use a total graphic user interface, users wrote with a light pen on an x-y pointer display, let users constrain properties in a drawing, created the use of "objects" and "instances"

PDGS
By: Ford
Ford and other manufacturers started releasing internally developed CAD/CAM systems

SynthaVision
By: MAGI
First commercially available 3D solid modeling program

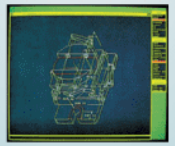
ComputerVision
By: Dr. Kenneth Versprille
Rational B-spline geometry added to CAD

CADAM
Used by Lockheed, introduced CAD to aerospace design

MiniCAD
Best selling CAD software for Mac computers

GEOMOD
Featuring NURBS
SDRC developed GEOMOD, their geometric modeling product. This m generator was b on preci and acc

Pro/Engineer
(PTC C o)
First n stream CAD gram. t took the ide of chpad and m it cc to life bas n sc mod histo ased ture and th se of const ints, was a huge turn in AD history



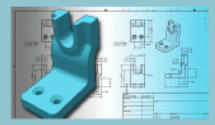
toCAL
R
Made the Autodesk program 3D

eCATALOG
By: CADENAS PARTsolutions
CADENAS enters the native 3D CAD model market with eCATALOG solutions digital product catalogs that featured multiple Native CAD formats for the first time

eCATALOGsolutions

Solid Edge
By: Siemens
Made as a PLM software, functions on Windows, provides solid modeling, assembly modeling, and 2D orthographic view, response to the success of SolidWorks

Autodesk Inventor
Autodesk's new direction, tried to be more intuitive and simple, also allowed the creation of complex assemblies in record time, still in use, really upped the game in the CAD world



3D CAD App
First APP for 3D CAD manufacturer models by CADENAS

Onshape
Completely cloud based CAD program

CADENAS PARTsolutions
Helping manufacturers "future proof" their catalog by keeping current with future native formats, versions and revisions.

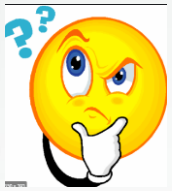
INTO THE FUTURE..

POPULAR CAD FORMATS

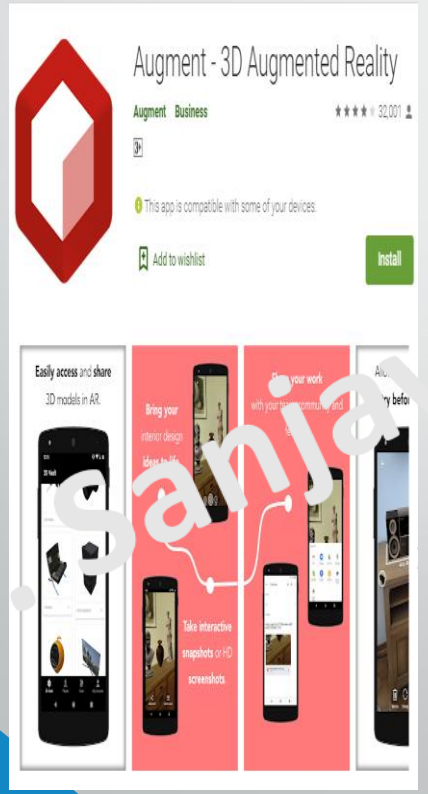
Source: https://partsolutions.com/60-years-of-cad-infographic-the-history-of-cad-since-1957/

Activity for students

What does Virtual Reality (VR) mean?

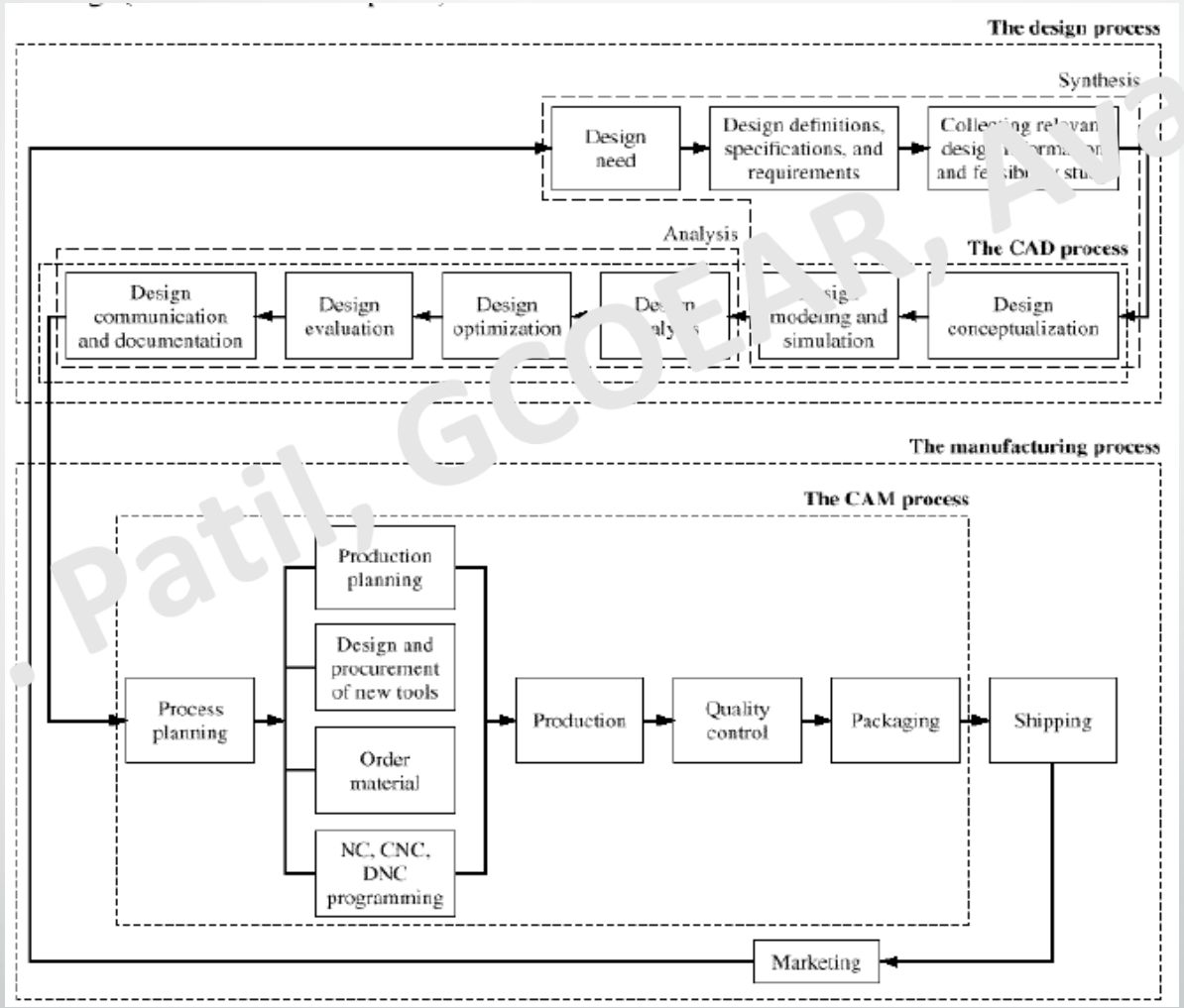


Download Augment app from Google play store and see, how the 3D model of product look in real environment..



Unit 1
Fundamentals of 3D Modeling

Product Cycle with CAD/CAM:



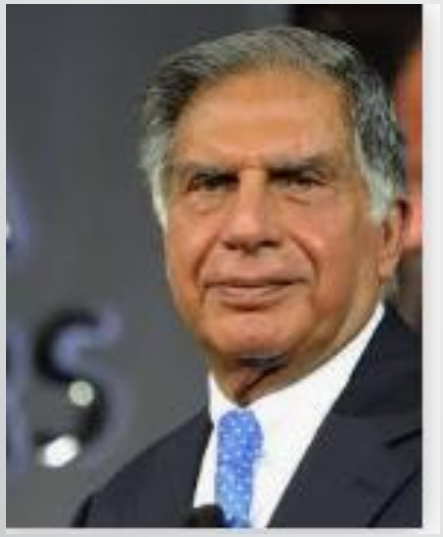
Typical Product Cycle with CAD/CAM

Sources : Mastering in CAD/CAM by Ibrahim Zeid

Case Study : TATA NANO Development

The People's car

Design Need



"I saw families riding around on scooter with kids standing up and the mother carrying baby and sitting pillion and decide to something about it. I stated as a quest for an affordable transports solution".

Source : Article The Economic Time dated Jan 11, 2008

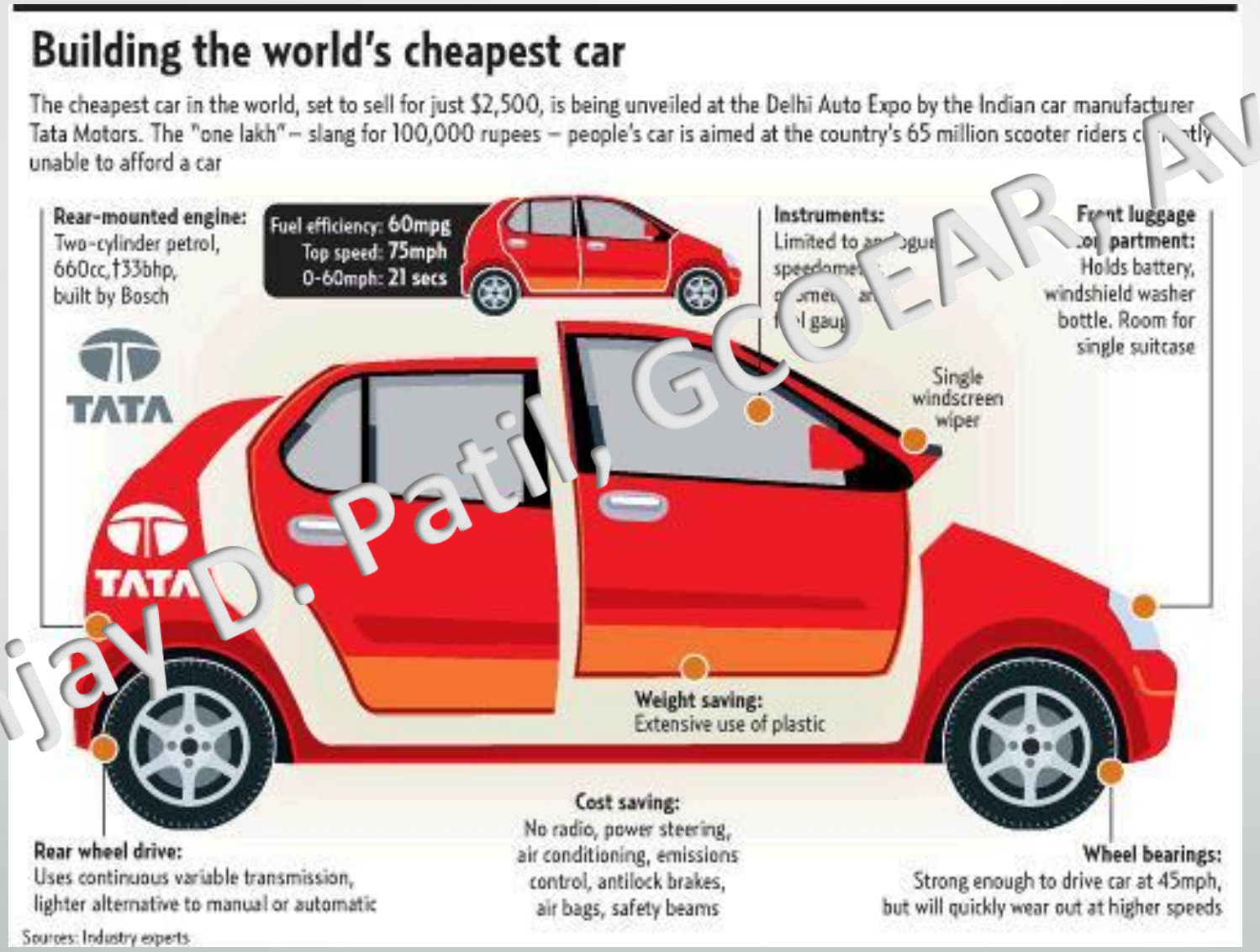
Design Definitions, Specification

- Affordable
- Meet safety requirement
- Fuel efficient

Concept/ alternative design testing and Development

- Scooter with 2 extra wheels
- 3 Wheeler car

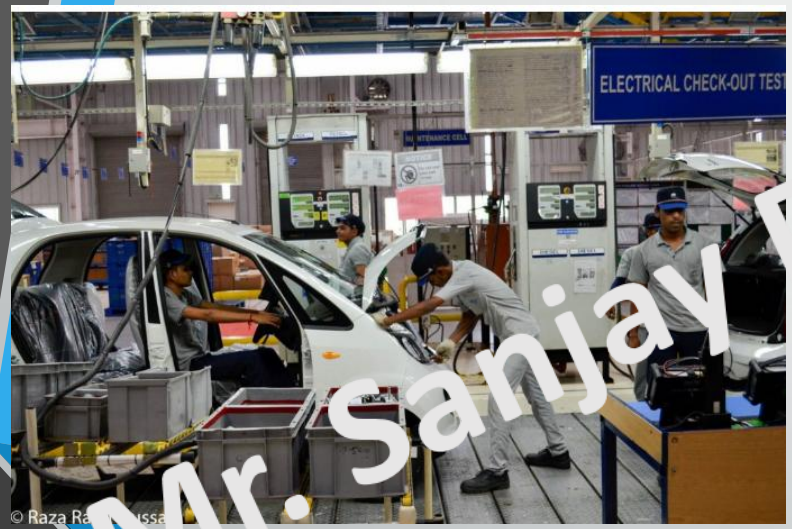
Design and analysis



Length	3.1 metres
Width	1.5 metres
Height	1.6 meters
Engine	All-aluminium, Rear Mounted, Rear Wheel Drive
Capacity	623 cc
Power	33 PS
Fuel Injection	Multi Point Fuel Injection (MPFI)
Fuel Type	Petrol, Diesel Version to be later
Body Type	Sheet Metal
Seating Capacity	04 (Four)
	20-22 Kmpl (City drive)
Mileage	26 Kmpl (Highways)
Top Speed	75 K.M
Emission Norms	Euro-IV, Bharat Stage-III compliant
Safety Norms	Frontal Crash Tested
Versions	One Standard and Two Deluxe

Tata Motors has applied for patent protection for over 37 inventions and innovations

(Source : ET 16march 2009)

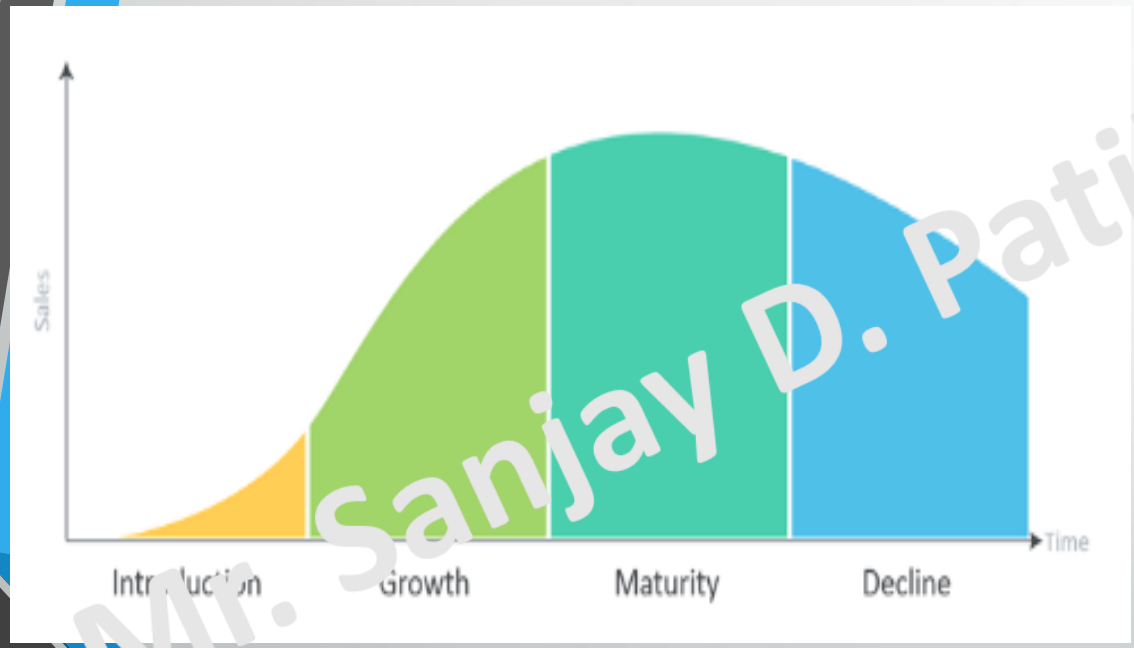


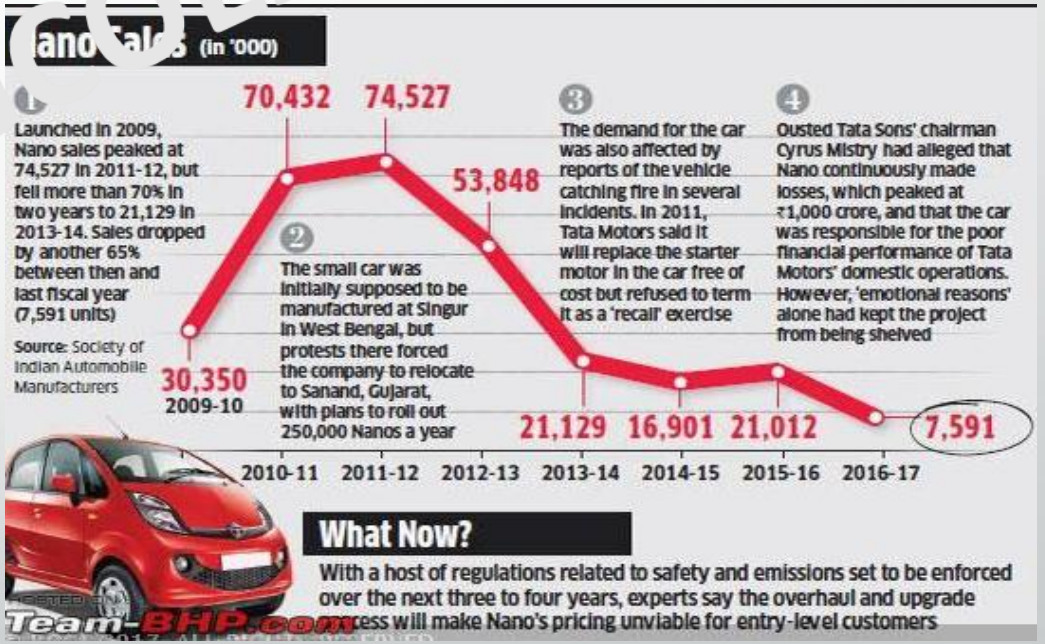
Tata Nano Sanand Assembly Plant

Source : https://www.ondrive.in/tata-nano-assembly-plant-sanand-gujarat.html

Product life cycle

Product life-cycle is the succession of strategies by business management as a product goes through its life-cycle.





Reference for case study : *a**WE**shkar Vol. XIX Issue 2, Sept 2015 WeSchool Dr. Swati Singh & Dr. Manoj Joshi*

Introduction:

The Nano car hit the Indian market in the 2008. It drew quite a lot of attention from the media across the globe and also Indians as it the “world’s cheapest car”. The sales target was to sell around 250,000 cars per annum in the year 2008.

Growth:

Tata nano saw an incredible amount of sales in the following year. It was the second best selling car in the 2011. With the factory output increasing from 30,000 to 70,432 to 74,52 in the year 2008, 2009 and 2011 respectively Nano was on its way to success

Maturity:

Nano had established itself in the Indian automobile market as it was bought most often. It also pushed the sales of Maruti 800 the next cheapest car down by 20%. This was seen was a greatest achievement as it had pushed down its retest competitor Maruti 800.

Decline:

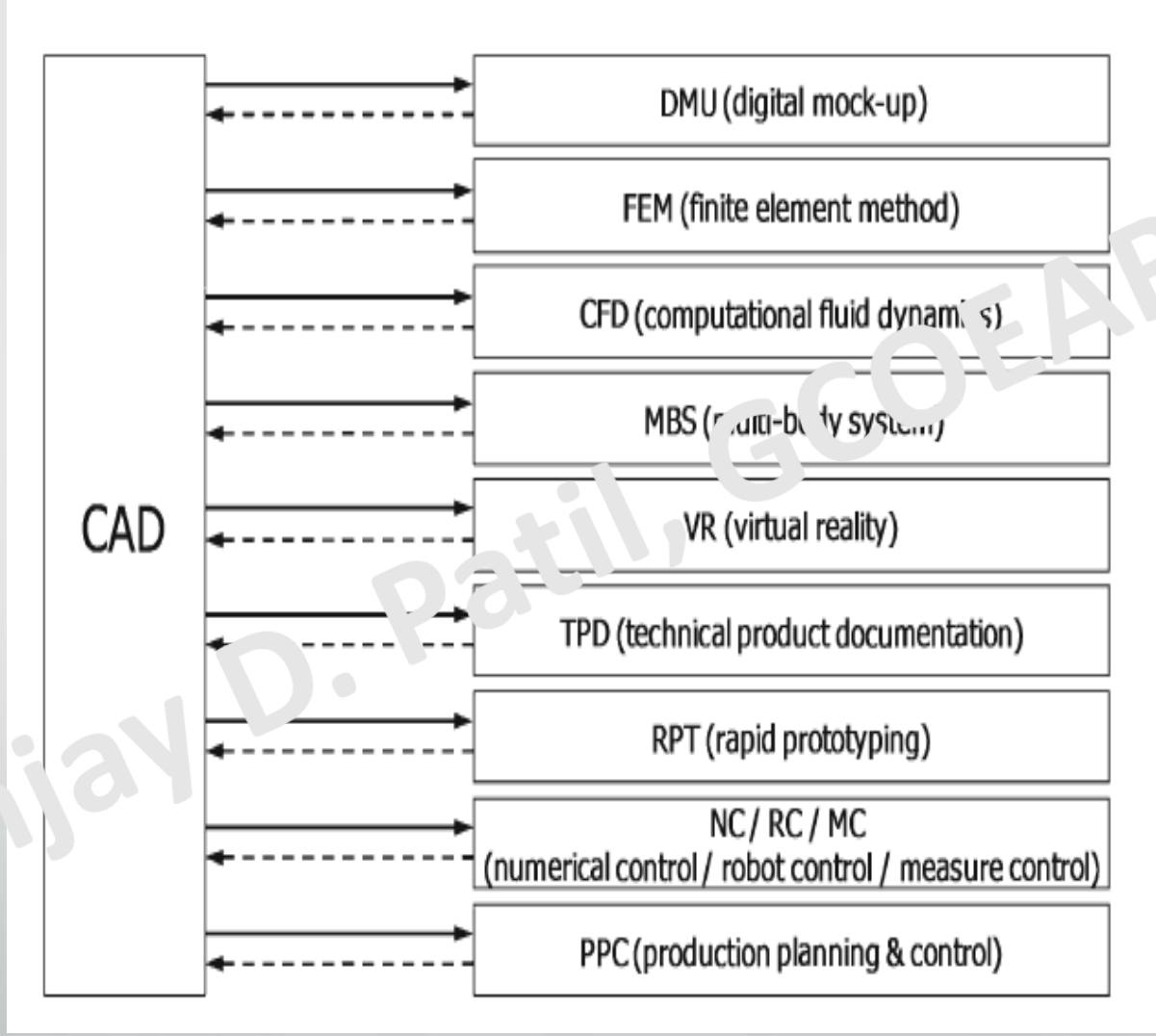
The product is very well in the market. It also launched a higher version of it product Gen X in 2014. However, the Nano faced lot of free economic cars launched by other player like Hyundai Eon, Maruti Alto which is also priced around the same figure as Tata Nano.

Reference : https://www.autopunditz.com/autopedia/gone-but-not-forgotten-series-tata-nano/#:~:text=If%20succeeded%3B%20it%20would%20have,and%20will%20always%20be%20remembered!

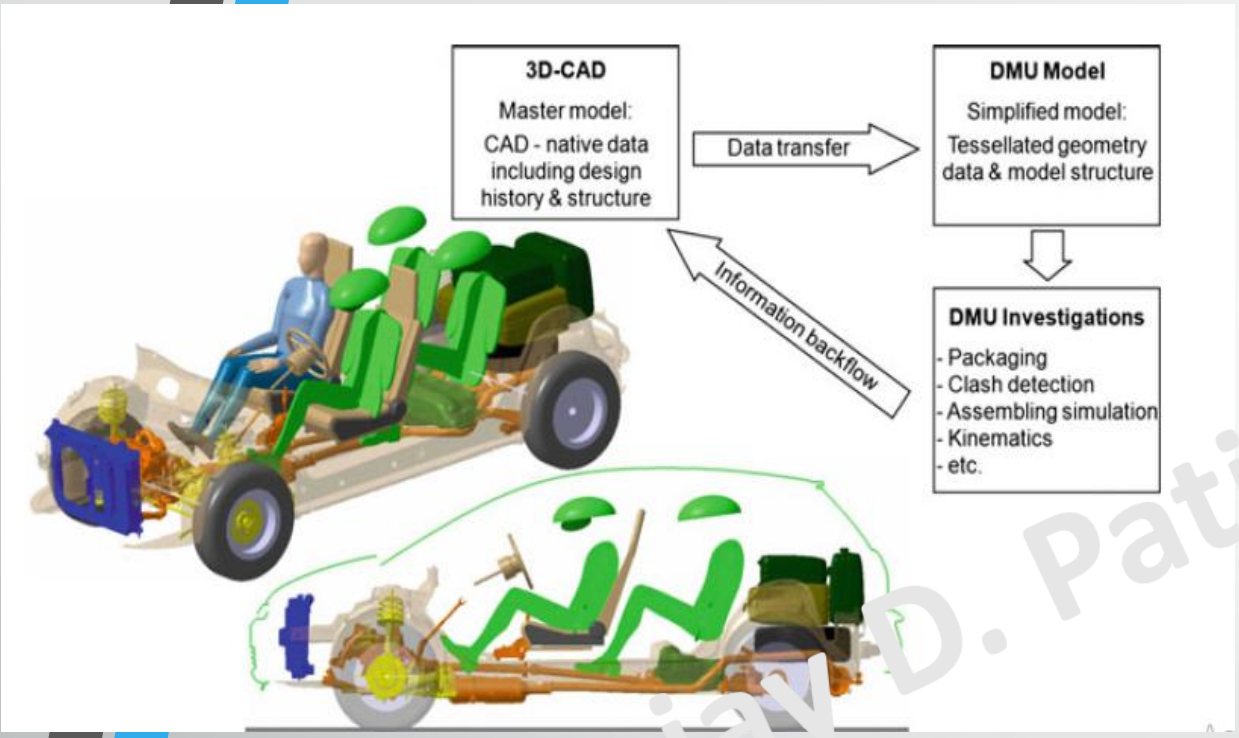
CAD tools in the design process of Product Cycle

Design Phase	Required CAD tool
Design Conceptualization	Geometric modelling techniques, graphics aids, visualization
Design modelling and simulation	Animation, assemblies, simulation and special modelling package
Design analysis	Analysis packages
Design optimization	Customized optimization, structural optimization
Design evaluation	Dimensioning, tolerances, BOM
Design Communication	Drafting and detailing, shaded images

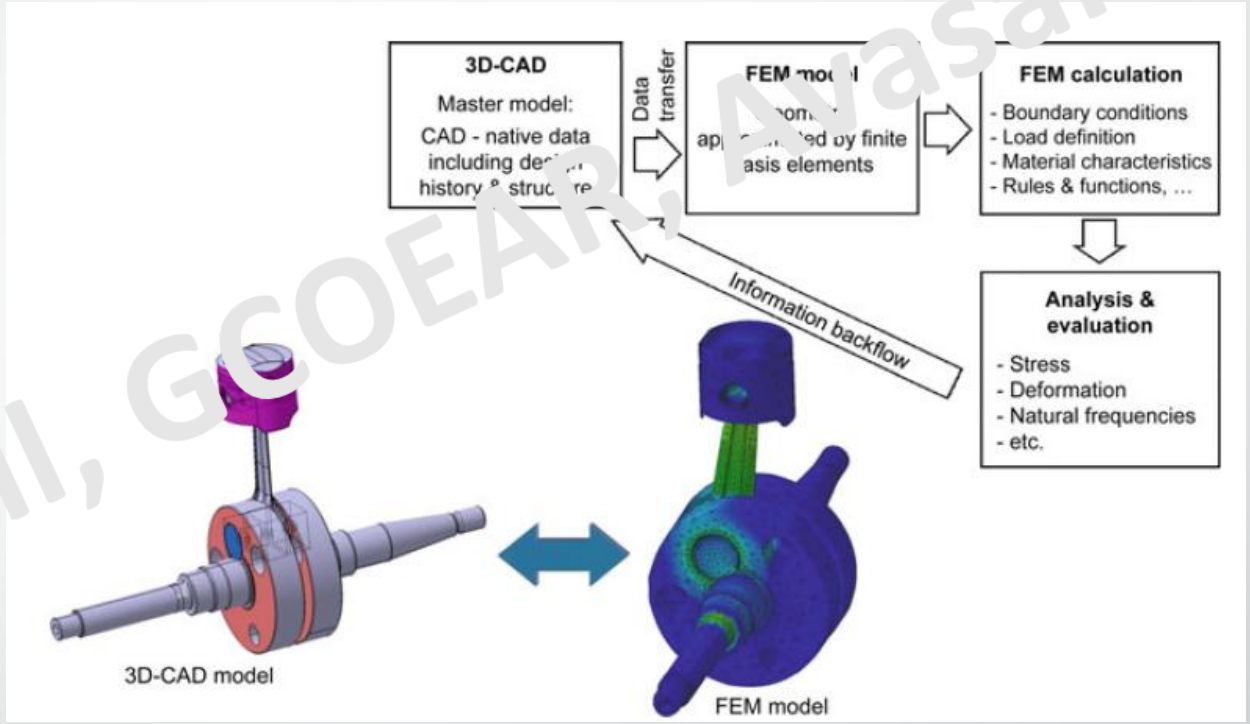
Scope of CAD



Scope of CAD

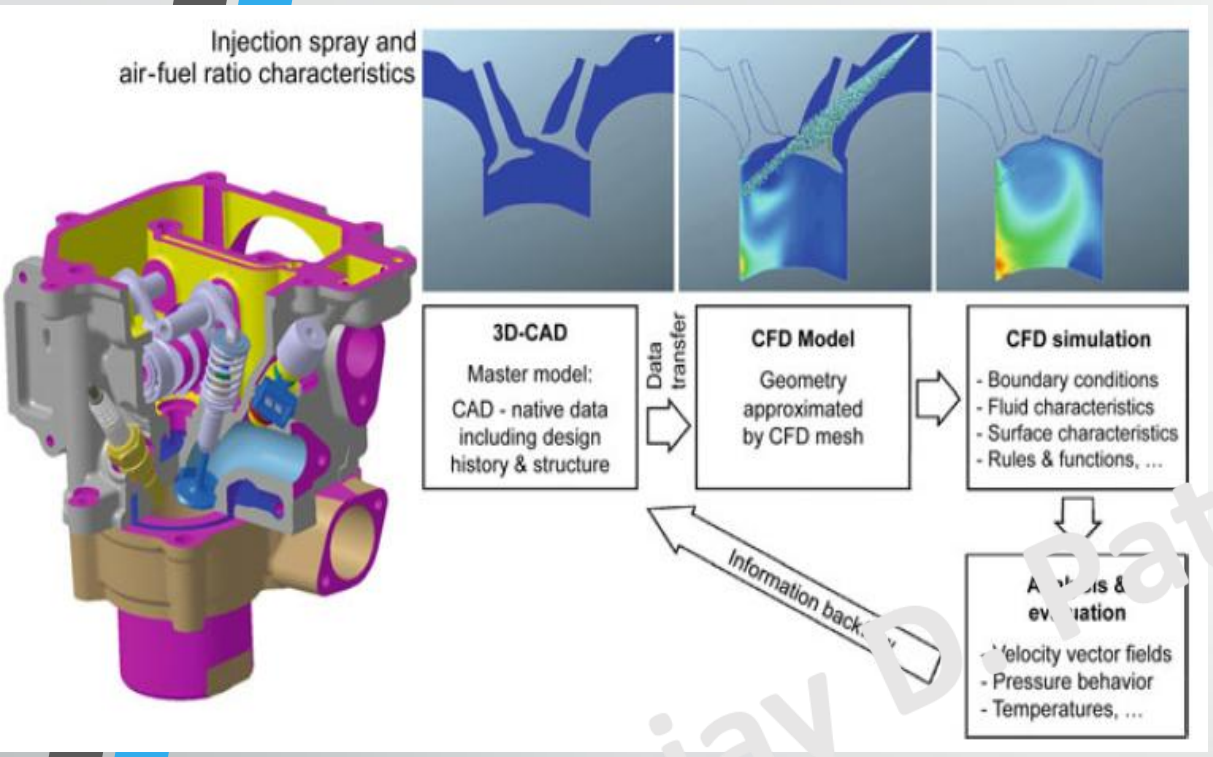


Digital Mock-up

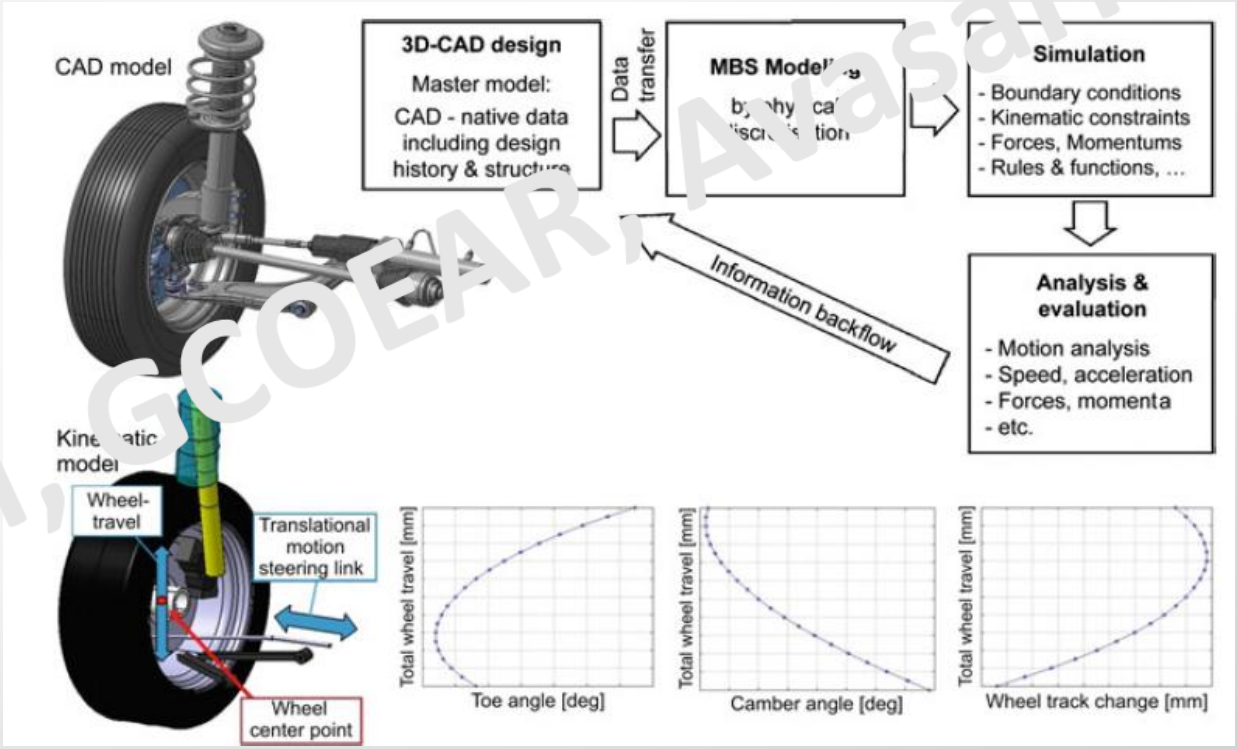


FEA

Scope of CAD

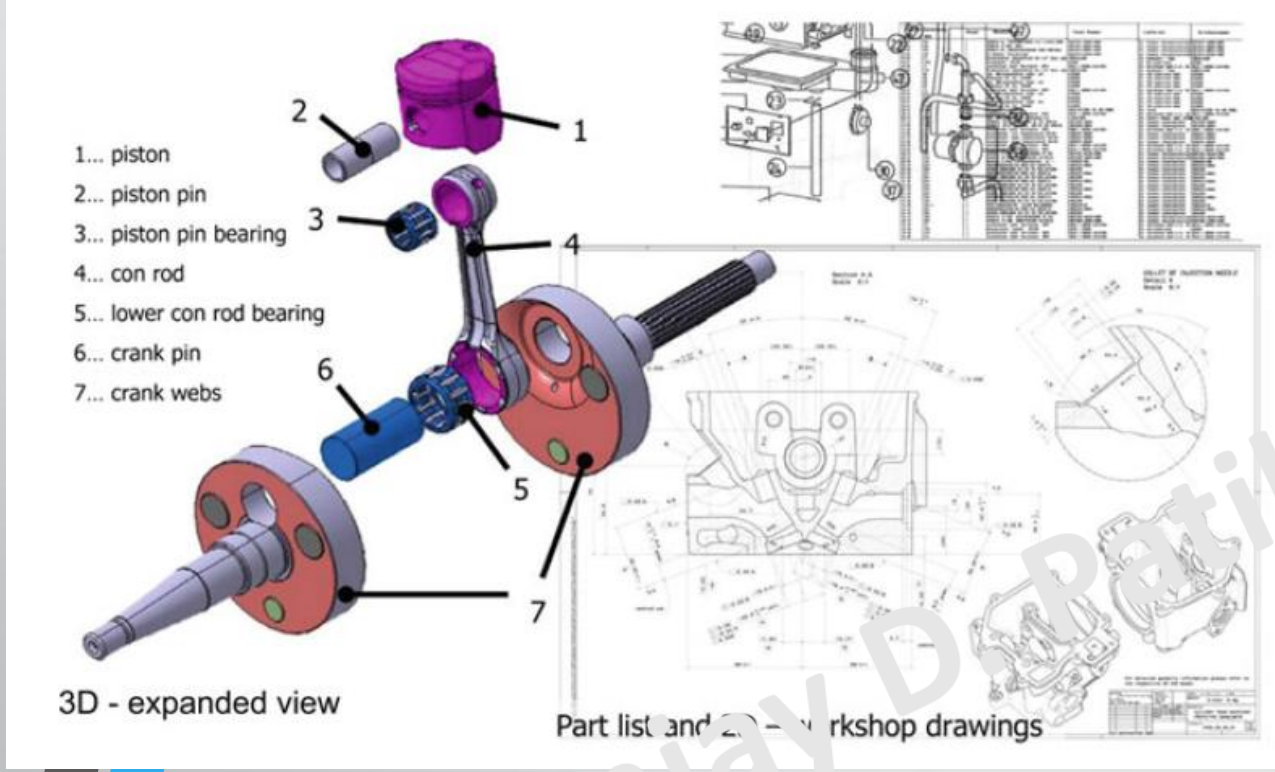


CFD

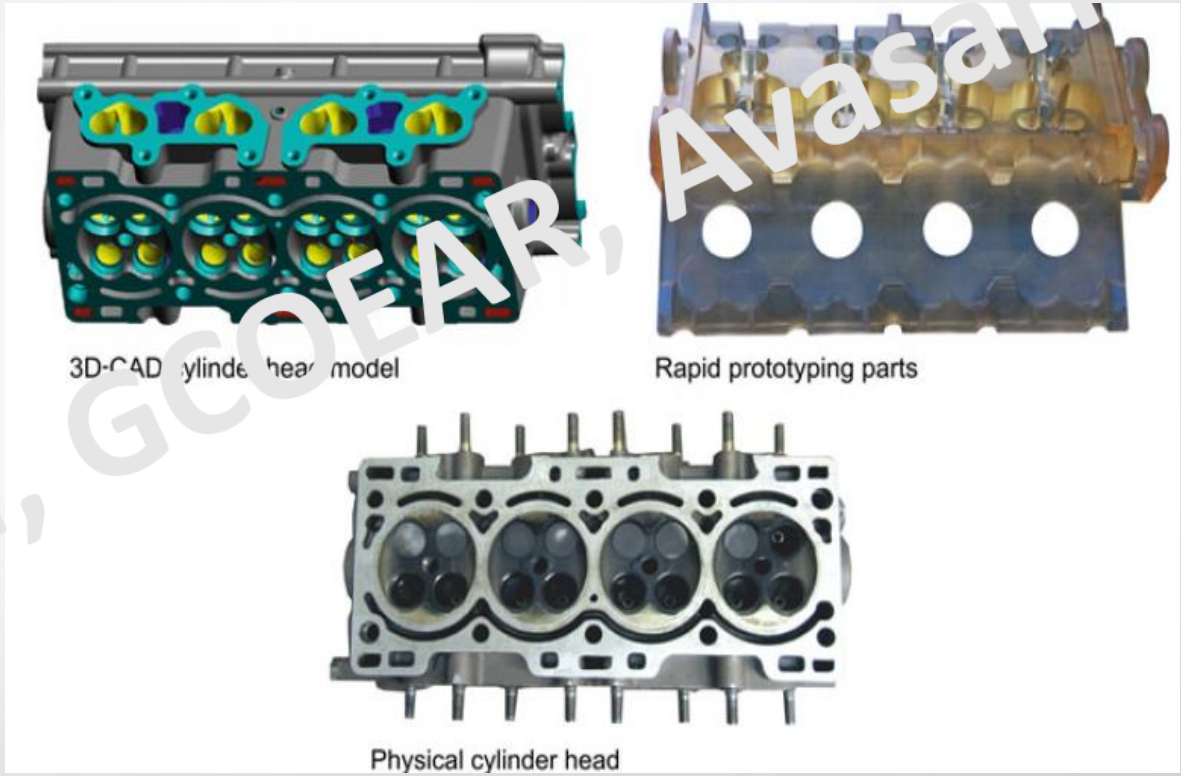


MBS

Scope of CAD



Technical Product Documentation



Rapid prototyping

Source: Mario Hirz , Wilhelm Dietrich, Anton Gfrerrer , Johann Lang Integrated Computer-Aided Design in Automotive Development

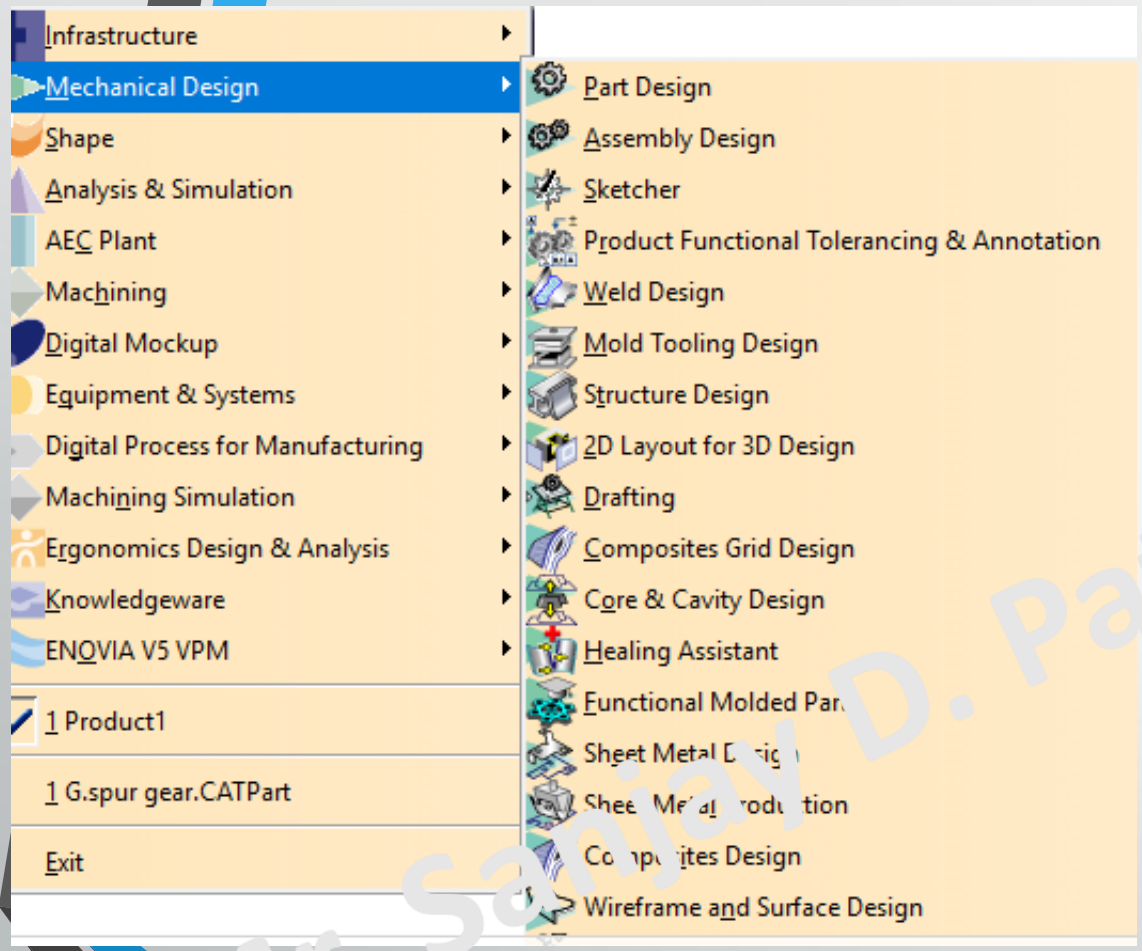
Software Module

- Each CAD software has its own strength and it usually targeted toward as specific market and group, accordantly the software modules are design.
- All CAD software has nearly a same genetic structure and common modules

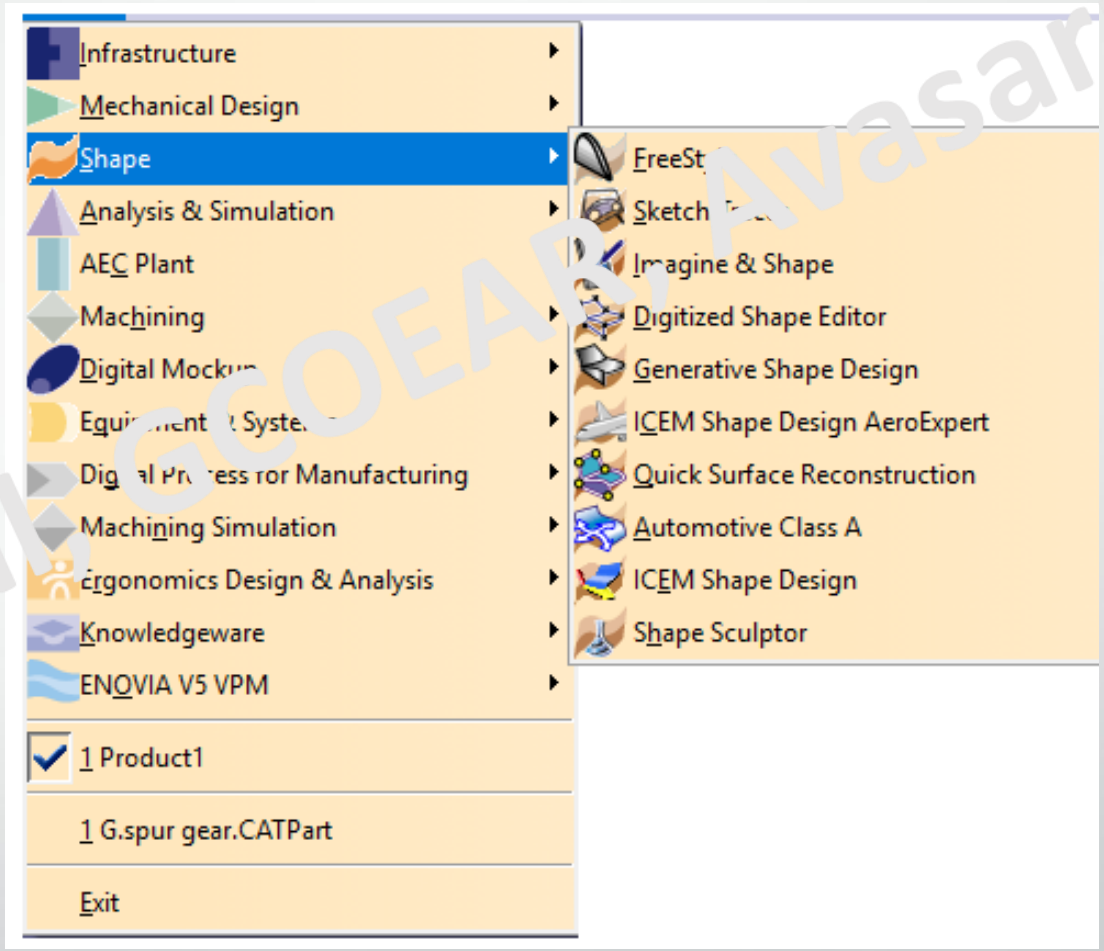
E.g. CATIA

- Computer-Aided Three-Dimensional Interactive Application (CATIA)
- Developed by the French company Dassault System
- CATIA use by a wide variety of industries,
  - Aerospace
  - Automobile
  - Mechanical
  - Shipbuilding
  - Energy, process and utilities
  - Architecture
  - Electrical system etc

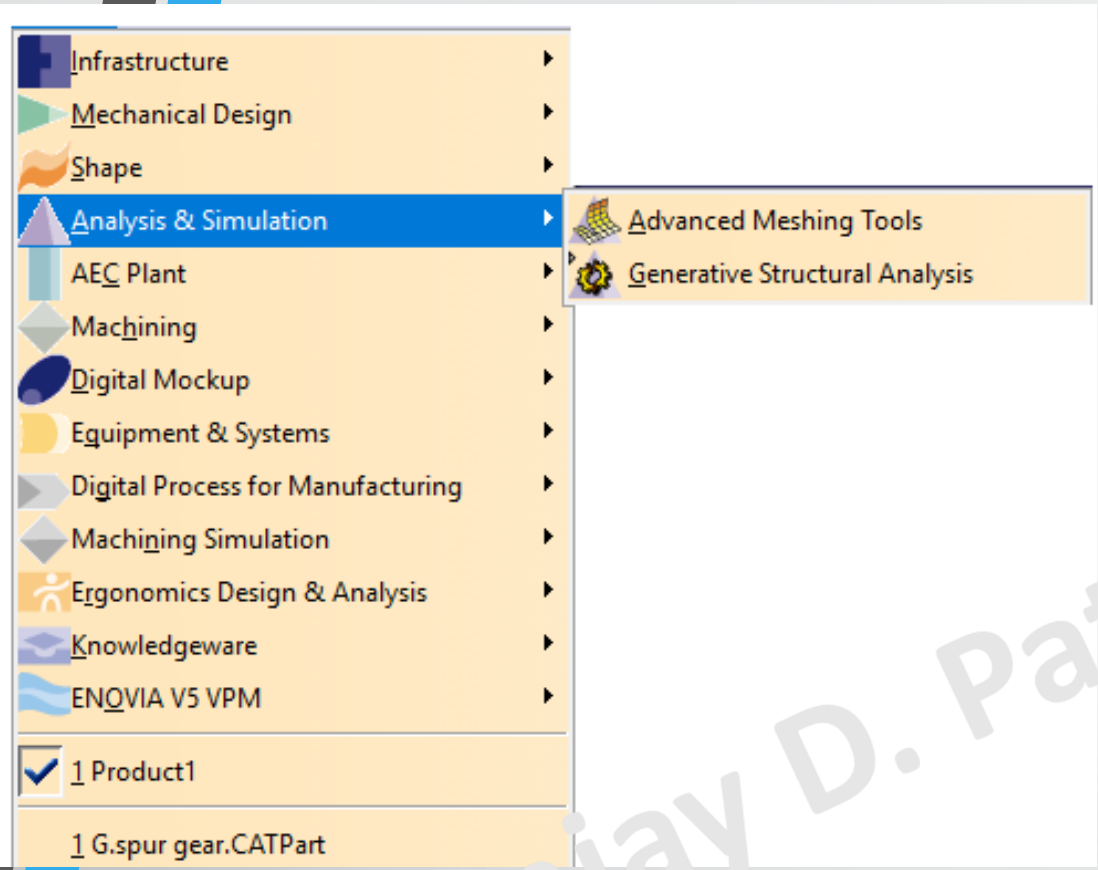
Important modules of CATIA



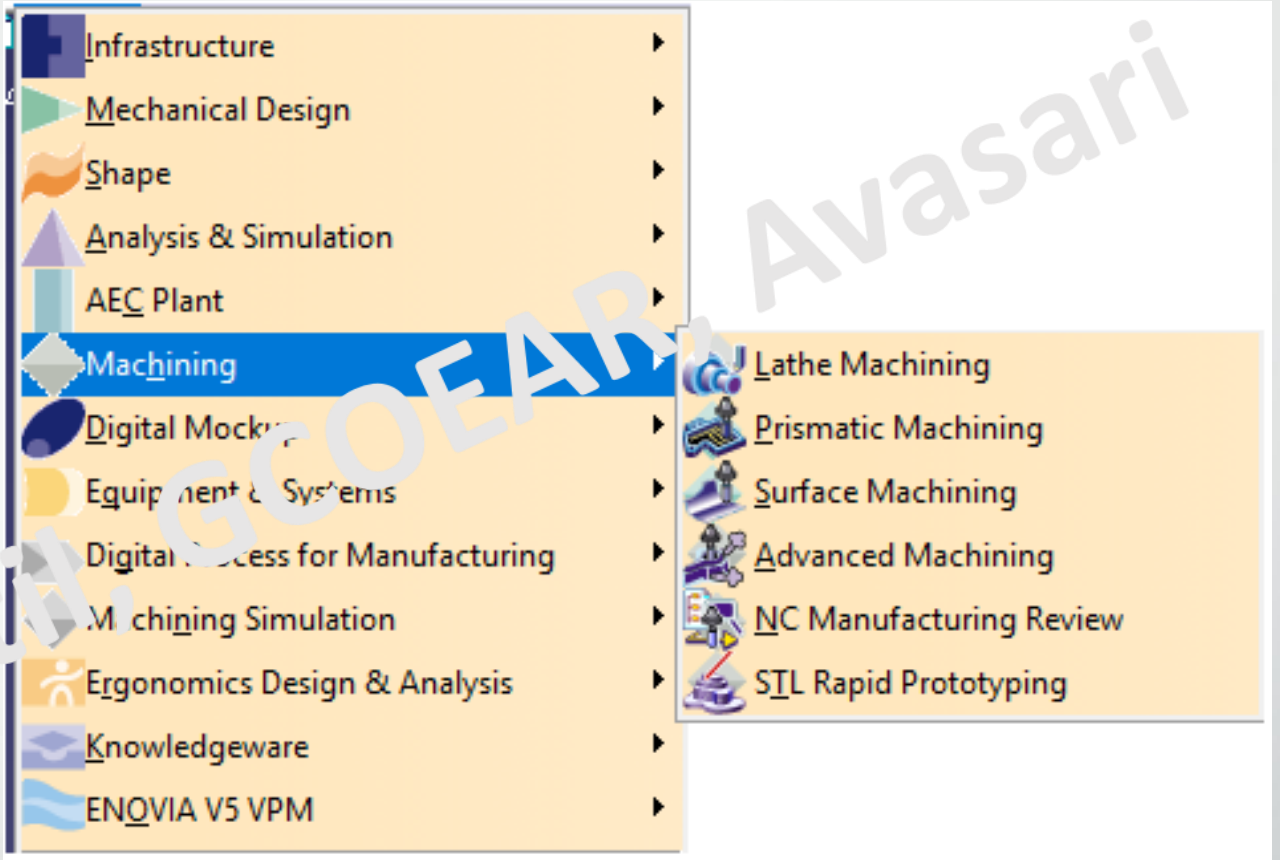
Mechanical design



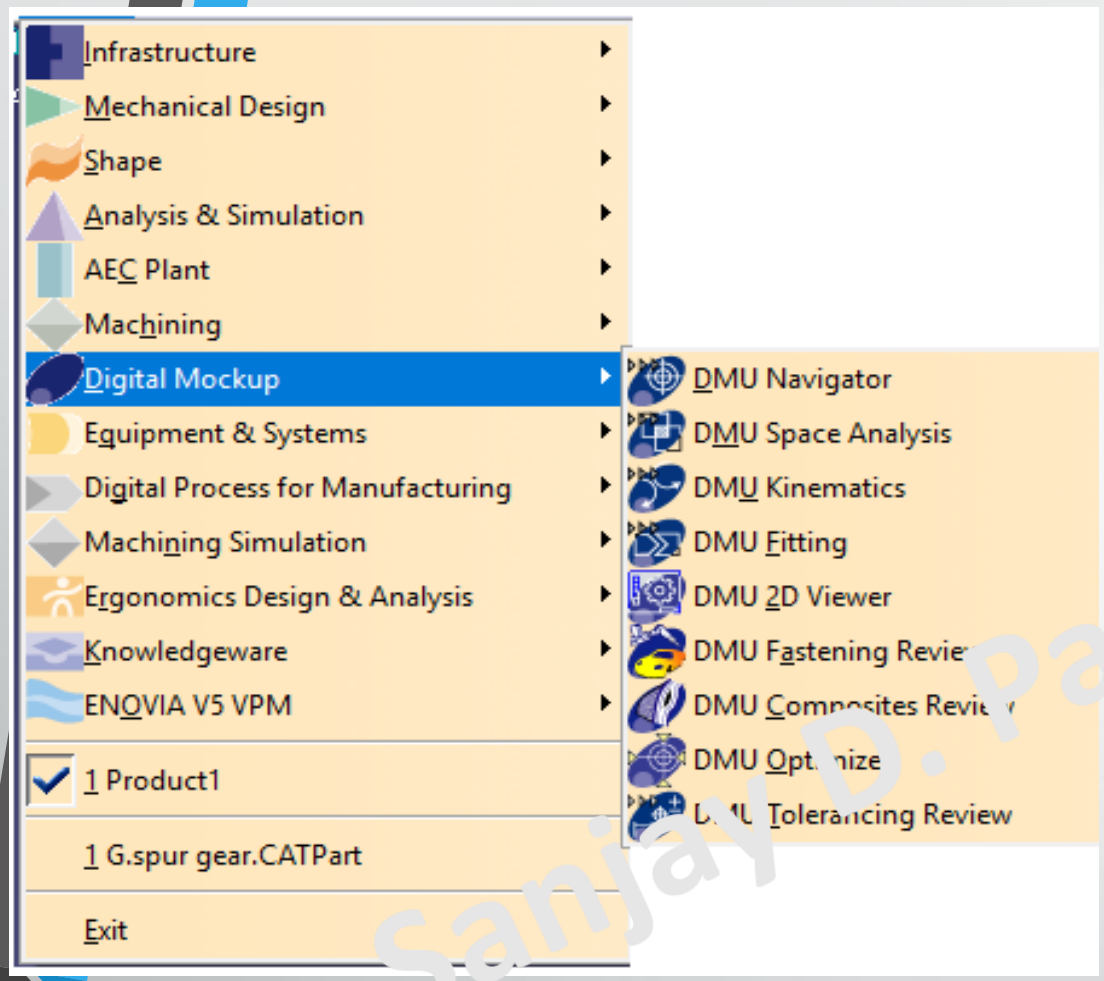
Shape Design



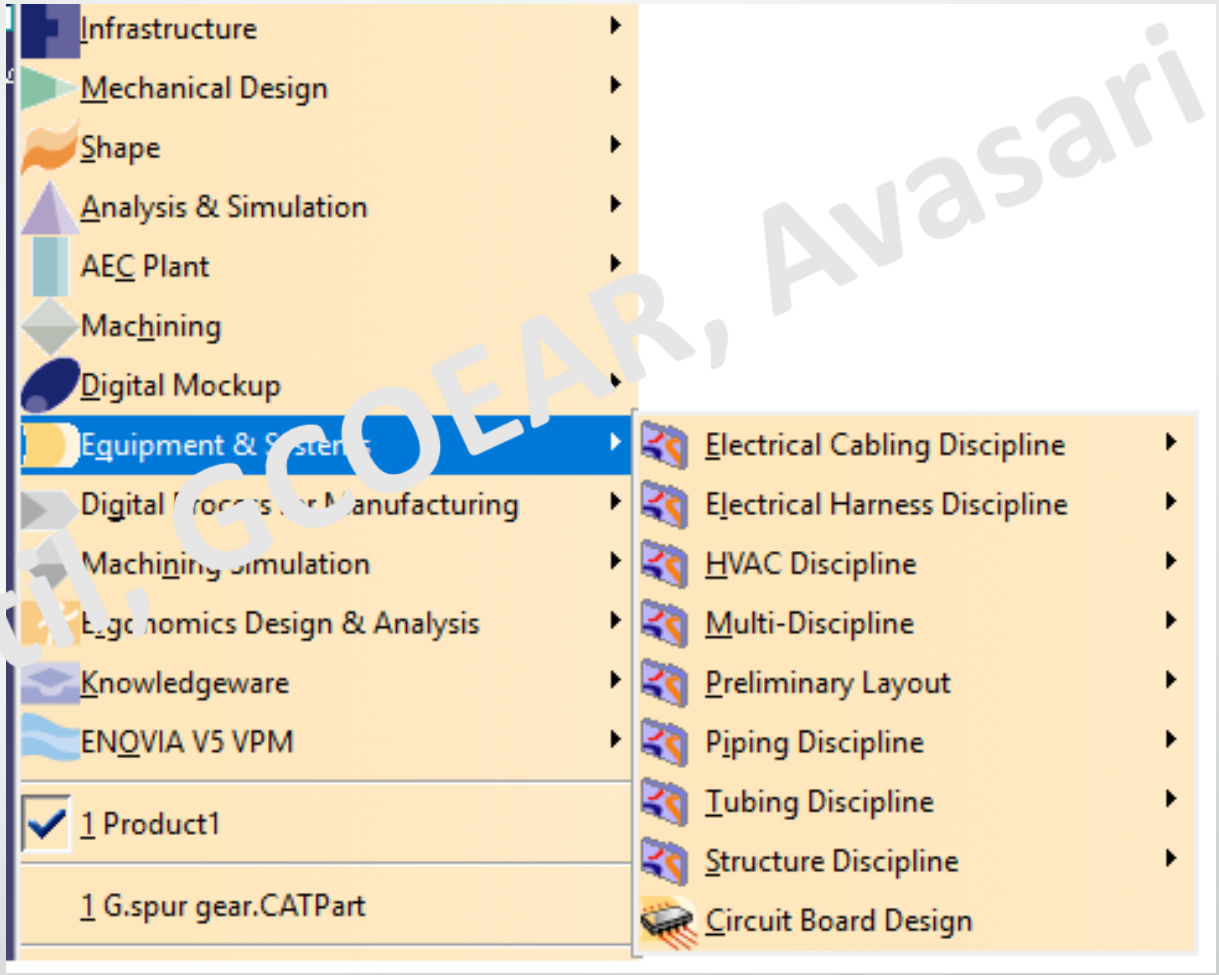
Analysis & Simulation



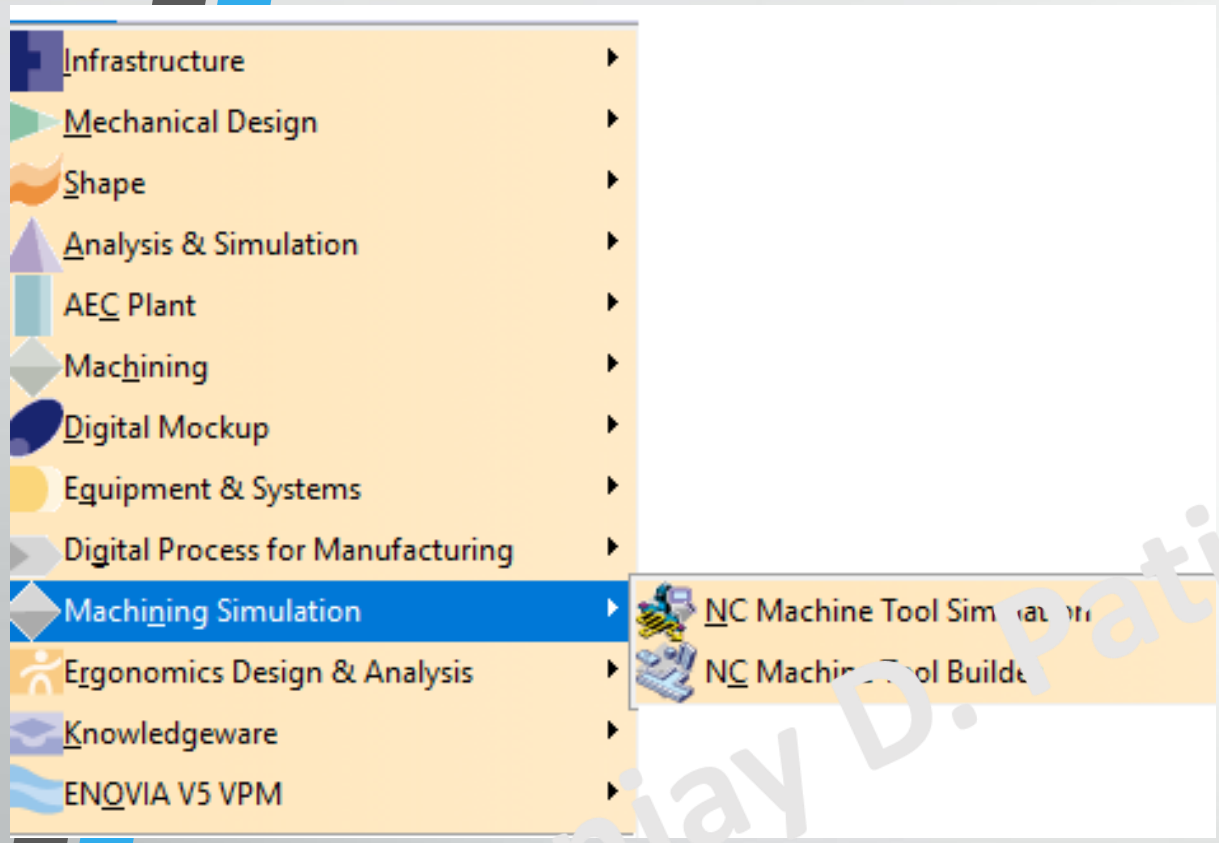
MACHINING



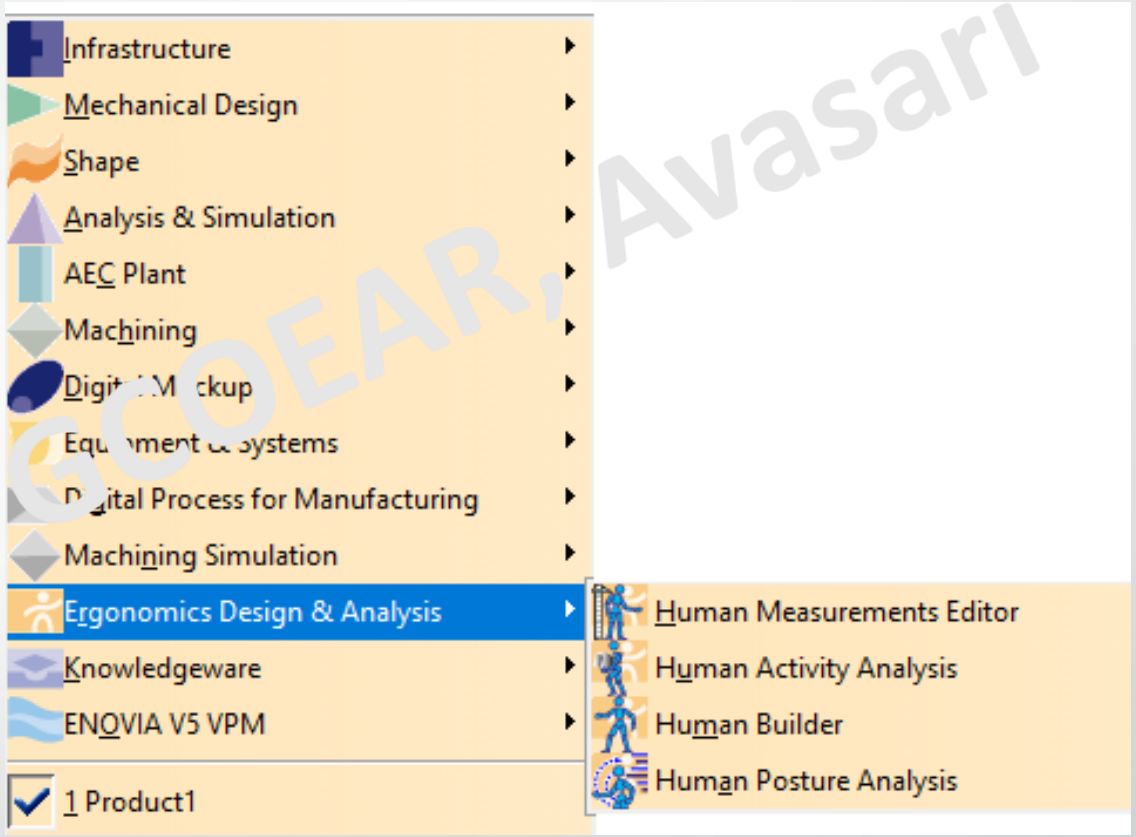
DMU(Digital Mockup)



Equipment & Systems



Machining Simulation



Ergonomics Design & Analysis

Broad classification of CAD software Module

Software Modules	Modules Function	Examples
Operating system	Utility and system commands	File manipulation, managing directories etc
Geometric Module	Geometric modelling, editing, manipulation, drafting documentation	Model creation, clean up, plotting etc.
Application module	Use model for design and manufacturing purpose. Analysis, Animation, NC simulation	FEA, tolerances analysis etc
Programming module	Customize system to fit certain design and manufacturing task	Autolisp, Macros
Communication module	Integration CAD/CAM system other computer system and manufacturing facility	IGES, STEP
Collaborative Module	Various teams in different location can work on same part, assembly etc	Cloud working

3D Modeling

3D modeling is the process of developing a mathematical representation of any surface of an object in three dimensions via specialized software.

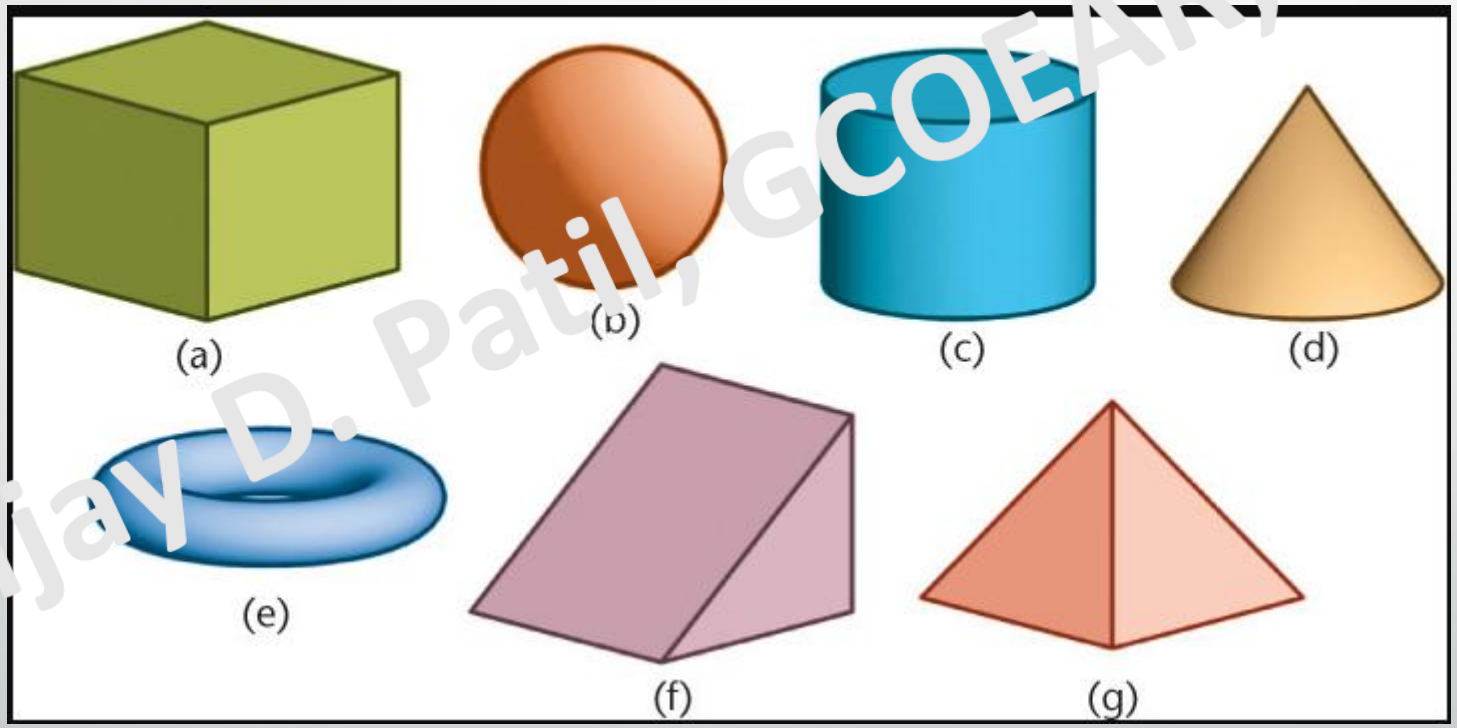
3D Modeling approach

- Primitive
- Feature
- Sketching

Primitive approach

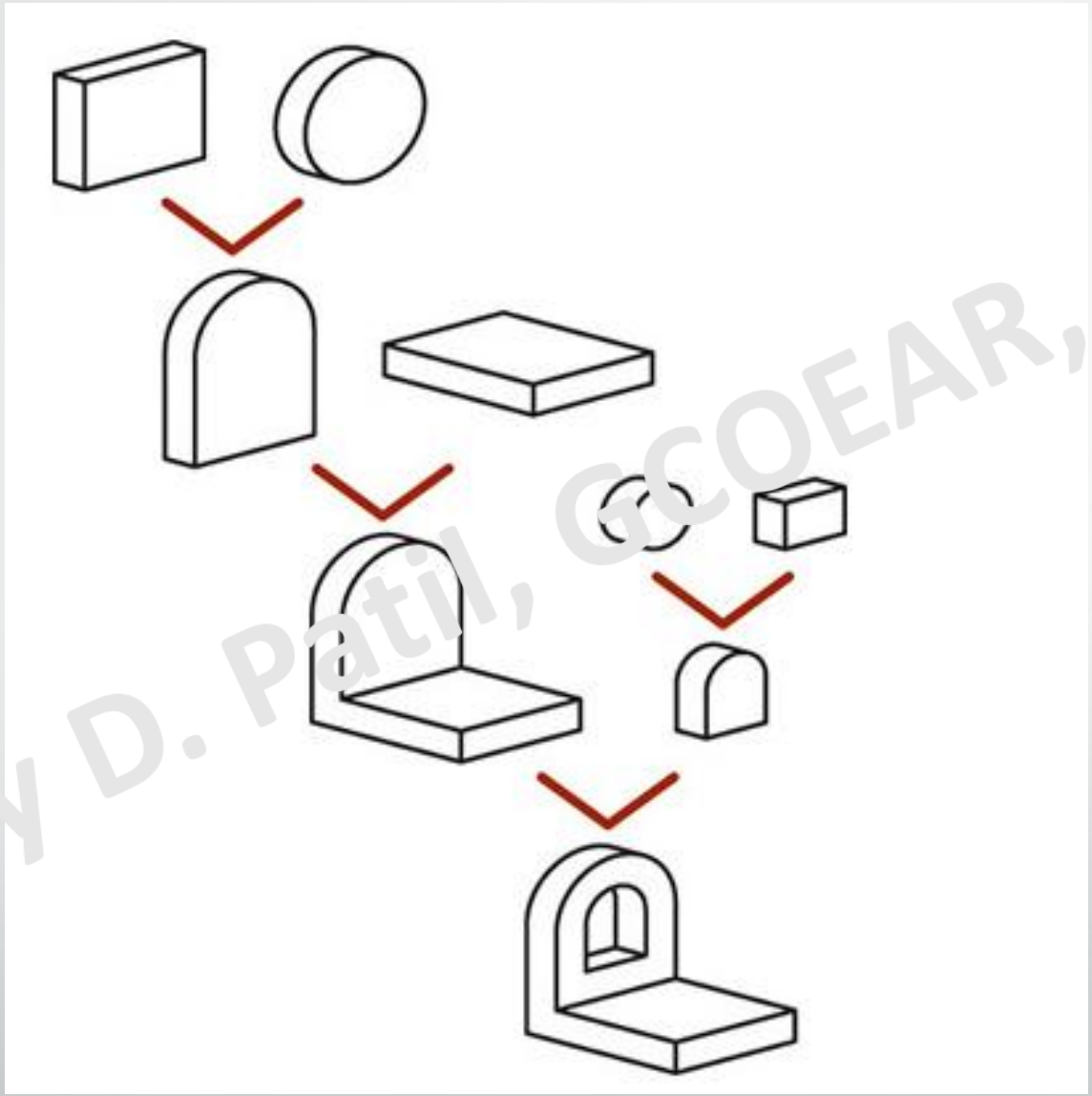
Primitives are the 3D building blocks, the basic geometric forms by using this block as it is or modify with transforms and Booleans operations.

Basic Primitive as below,



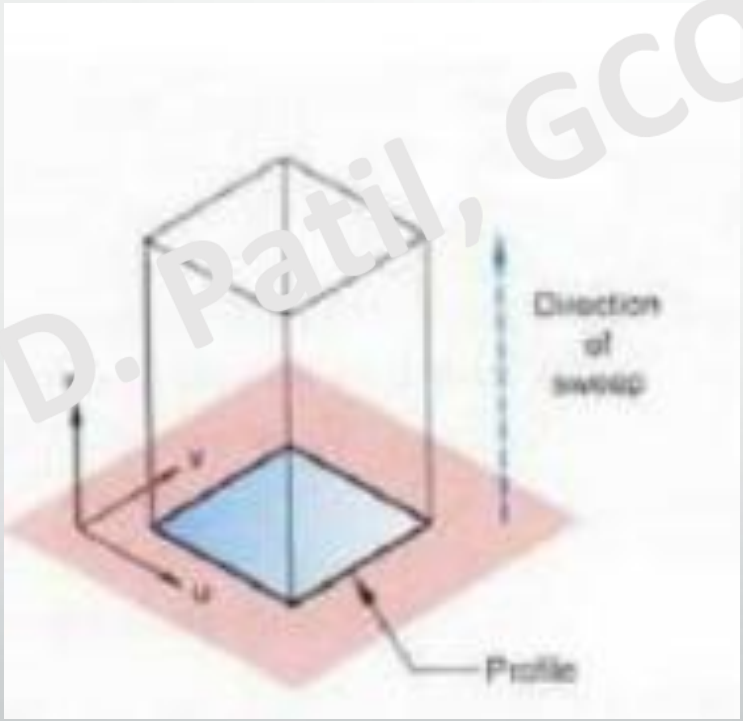
Primitive modeling

Continued...



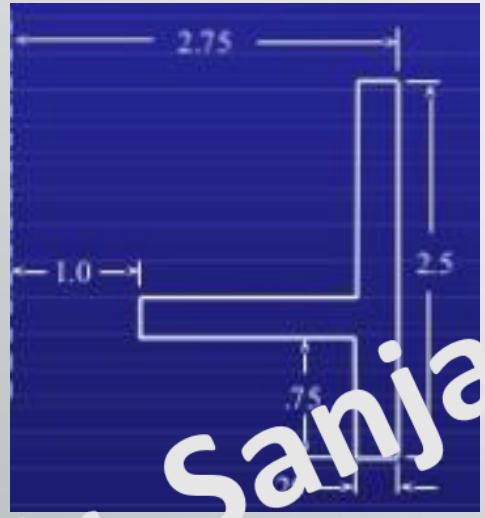
Features based approach

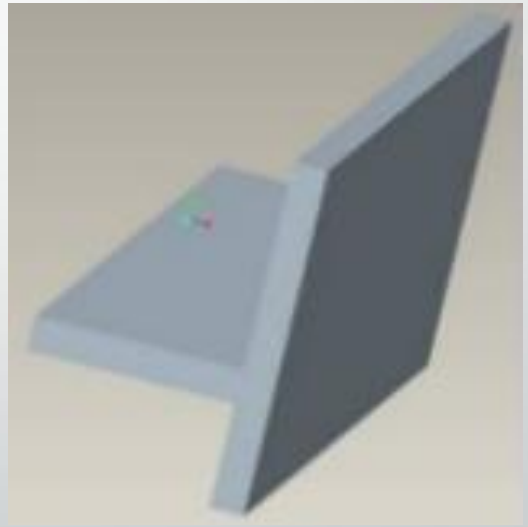
- It similar to primitive approach, It replace primitive with a feature and embed Boolean operation in the feature definition
- Each feature can be independed or linked to other feature
- The geometry of each feature is control by modifiable constraints and dimensions



Sketching approach

Users can express their intent by sketching 2D shape then various feature will be applied to generator 3D model.

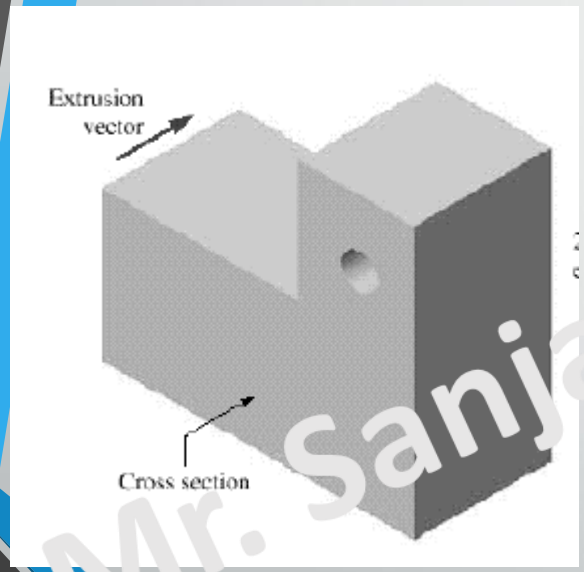




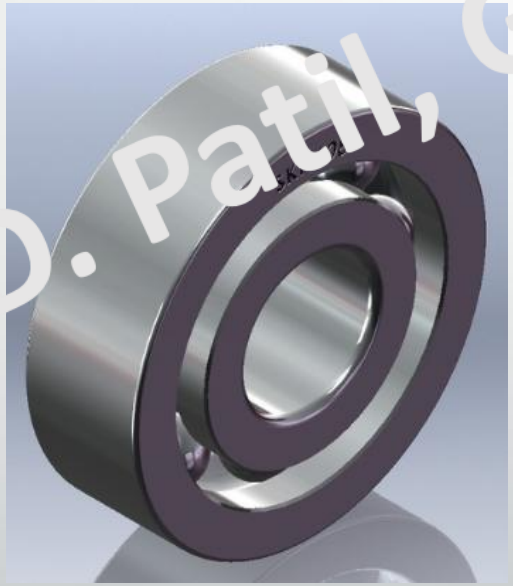
Type of Geometric model

2 ½ model

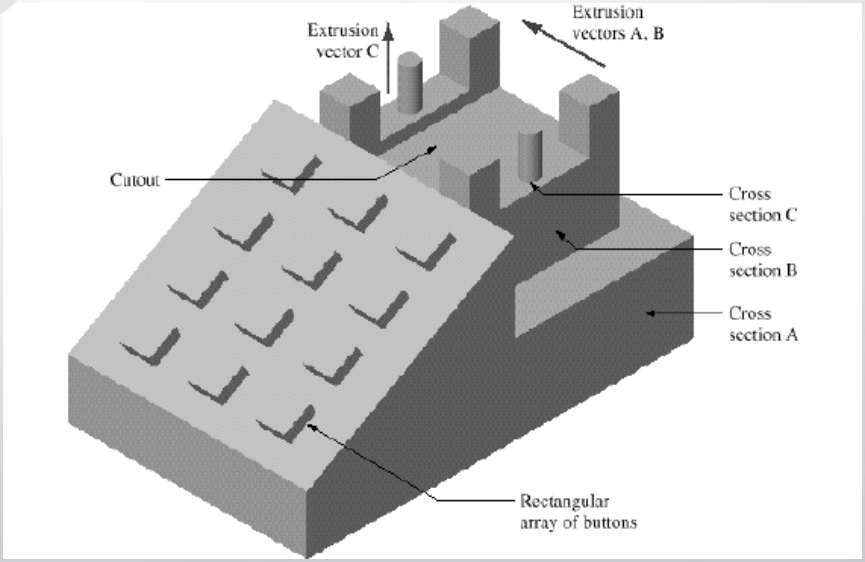
- Extrusion : Constant cross section and Thickness in a direction perpendicular to the plan of cross section
- Axisymmetric : Constant cross section about the axis of revolution
- Composite : It is combination of extrusion and axisymmetric



Extrusion



Axisymmetric



Composite

3D Object

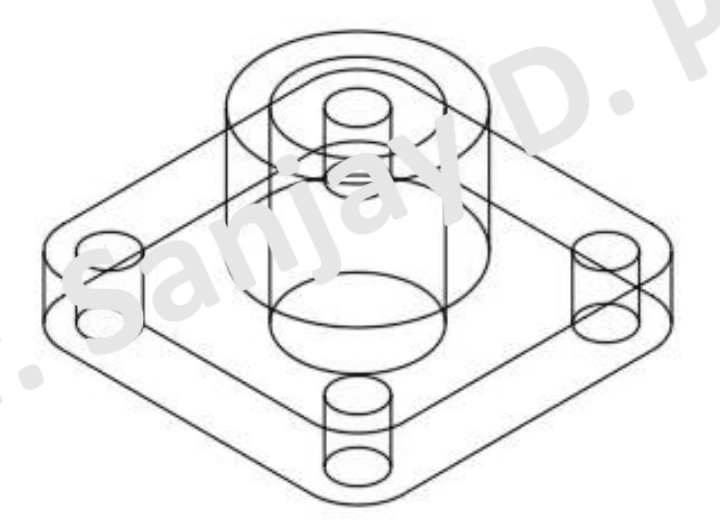
Does not have any geometric uniformity like in 2 ½ models

3D Geometric Modeling Techniques

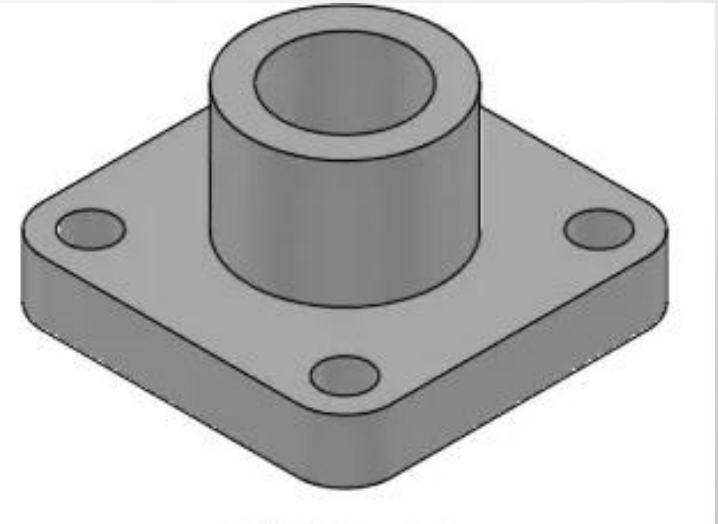
There are basic the three types of 3D geometric modeling techniques,

Wireframe Model

- A wireframe representation is a 3-D line drawing of an object showing only the edges without any s[illegible]urface in between.
- A frame constructed from thin wires representing the edges and projected lines and [illegible]
- Contains information about the location of all points and edges in space c[illegible]
- Each vertex is defined by x,y,z coordinate
- Edges are defined by pair of vertices
- Faces are defined by three or more edges



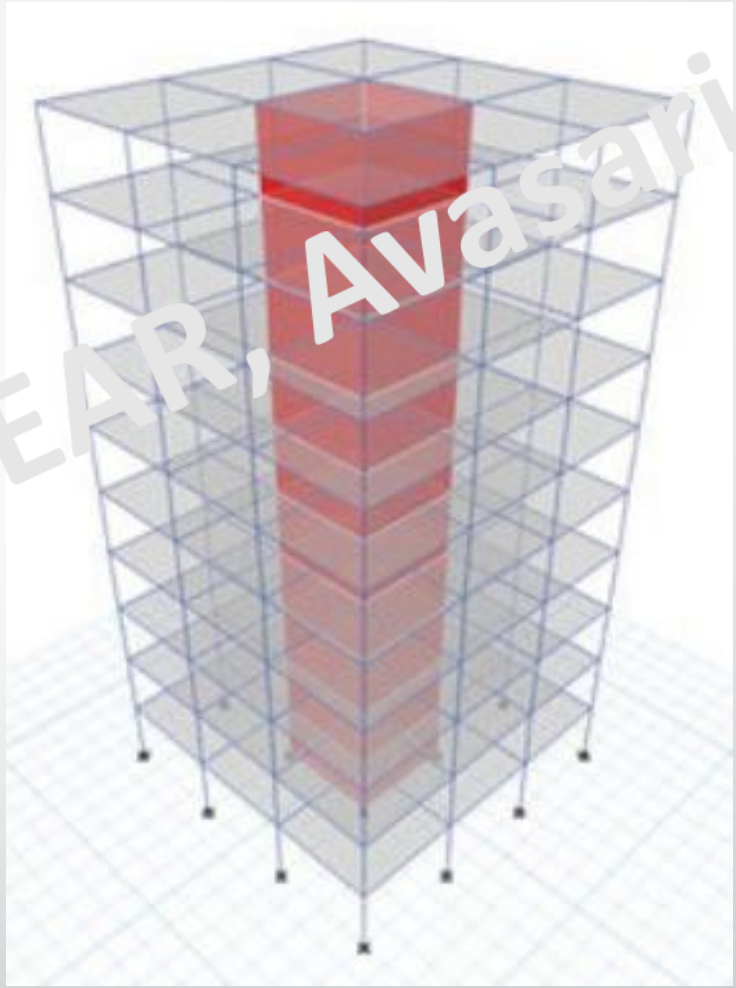
Wireframe 3D model



3D Solid model

Advantage Wireframe Model

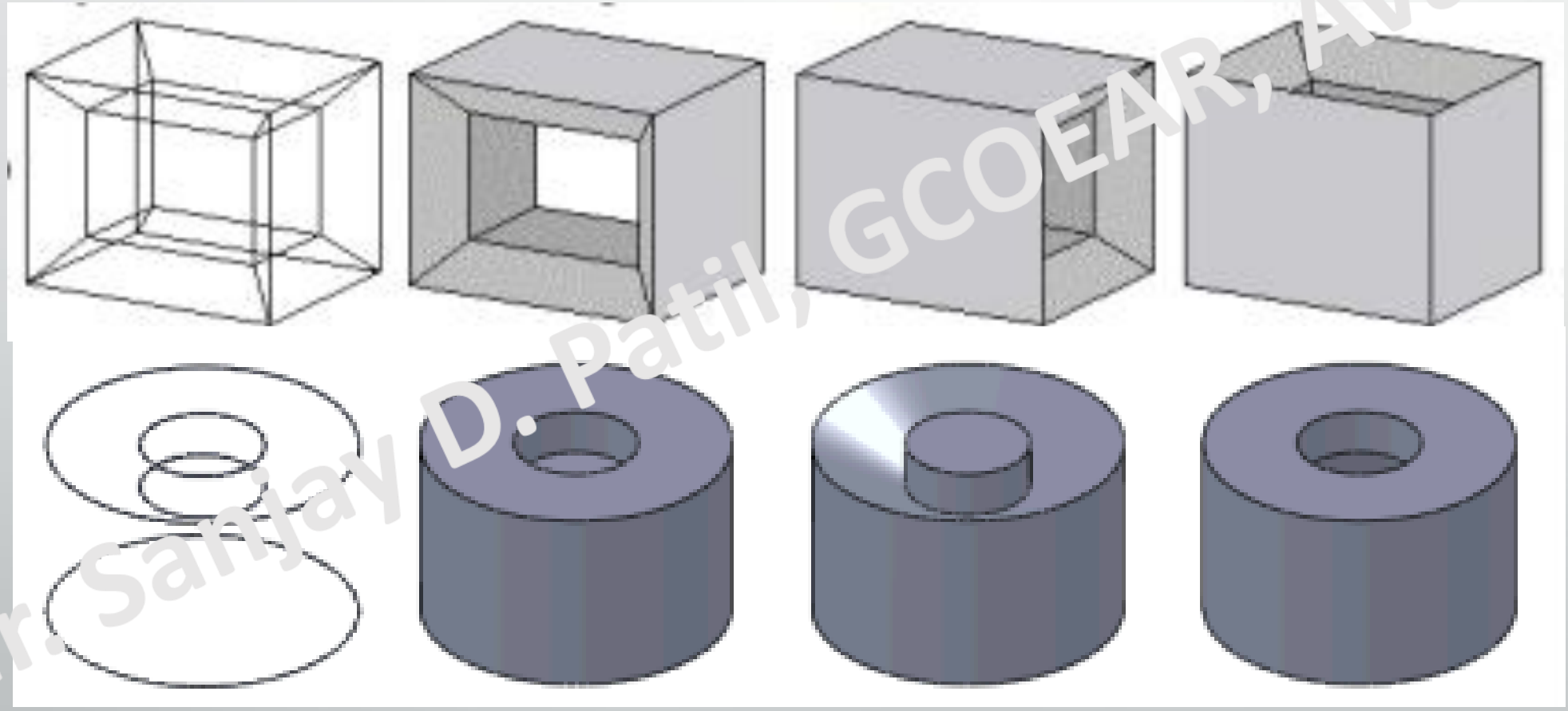
- Can quickly and efficiently convey information than multiview drawings.
- The only lines seen are the intersections of surfaces.
- Can be used for finite element analysis
- Can be used as input for CNC machines to generate simple parts.
- Contain most of the information needed to create surface, solid and higher order models



ETabs Building model

Limitation Wireframe Model

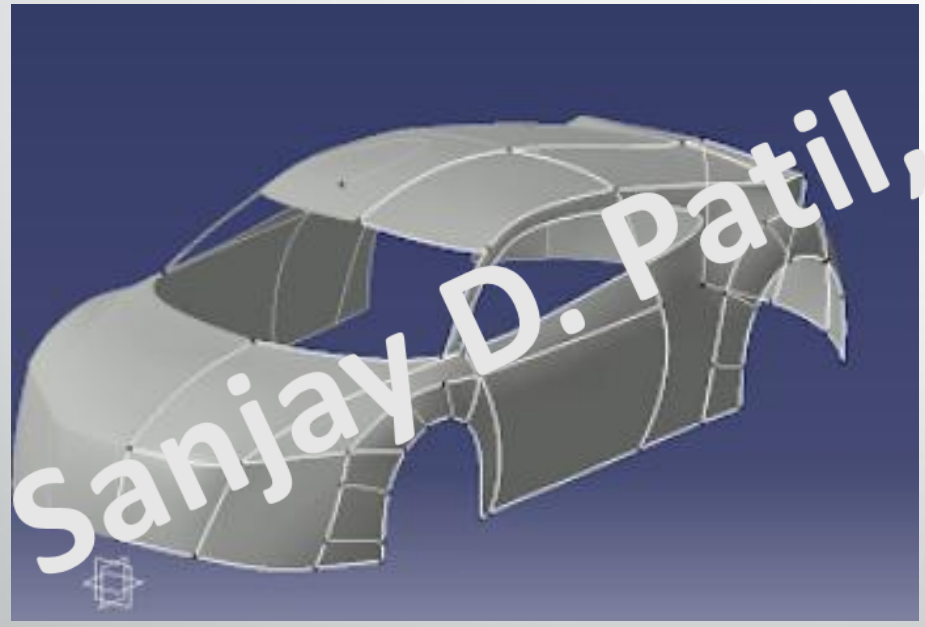
- Ambiguities present in the wireframe model



- Volume or surfaces of object not defined
- For complex items, the result can be a jumble of lines that is impossible to determine
- Limited ability for checking interference between mating parts.
- No ability to determine computationally information such as the line of intersect between two faces of intersecting models.
- Cannot be used to calculate dynamic properties

Surface Model

- A surface model represent the skin of an object, these skins have no thickness or material
- Surface model define the surface features, as well as edges of object
- Mathematical function describes the path of a curve



Surface Models

Advantage of Surface Model

- Eliminate ambiguity like wireframe model
- Can use for CNC machining mold and die design, FEA
- Typical applications of 3D CAD surface modeling include body design in automotive and aeronautic engineering and the representation of complex geometries
- Surface properties such as roughness, color and reflectivity can be assigned and demonstrated
- Volumetric properties of an object can be easily obtained

Limitation of Surface Model

- Surface models provide no information about the inside of an object
- Complicated computation, depending on the number of surfaces

Solid (Volume) Model

- Solid enable a complete and compact geometrical representation of object in a virtual environment
- Solid models are capable of defining closing conditions, inside/outside information and geometrical consistency specifications.
- It able to define material properties supports the realization of several physical simulations
- improves the quality of design improves visualization
- Simulation under real-life conditions and less expensive than building a physical model
- Can be used for presentations and marketing

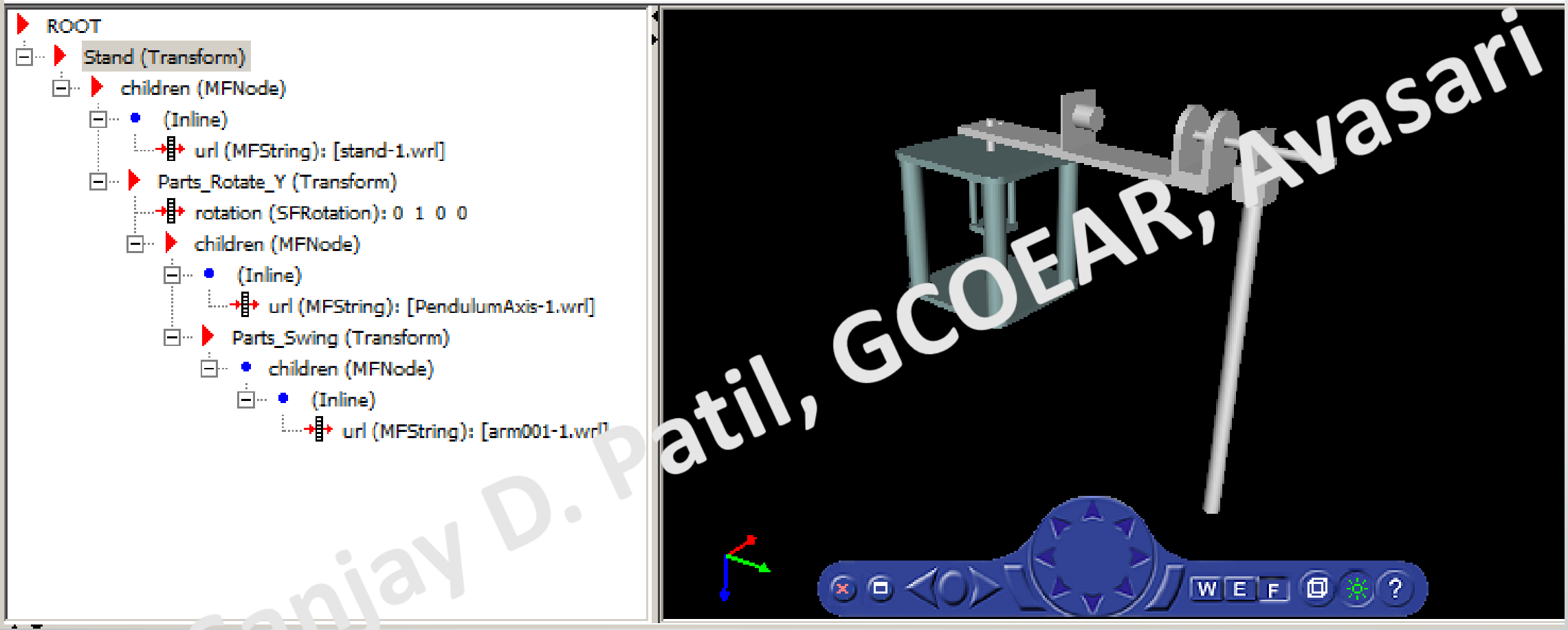
Modeling Strategies

In CAD software one type of 3D model is possible to create by N number of way but, best modeling strategies is a sequences of through about the easiest, fastest way to create geometric model. The guidelines of modeling strategies are bellow,

- Determine the model type and Subtype
- Observer geometric characteristics of model
- Choose the model orientation in 3D space
- Choose the model origin
- Decide the other geometrical details
- Avoid the unnecessary calculation

VRML (Virtual Reality Modeling Language)

- Enable to displace CAD model without CAD software
- Able to manipulate (rotation/move/zoom) the CAD model
- VRML (Virtual Reality Modeling Language), originally before 1995 known as the Virtual Reality Markup Language is a standard file format for representing 3D model in the World Wide Web
- VRML is a text file format where, e.g., vertices and edges for a 3D polygon can be specified along with the surface color, shininess, transparency, and so on
- Very useful for marketing engineer, client, customers etc.
- VRML files are commonly called "worlds" and have the *.wrl extension



Assignment

- A1 batch : Write the report on ‘ Used of the CAD software to design the college BAJA vehicle’
- A2 batch : Write the report on ‘ Used of the CAD software to design the college Go-kart vehicle’
- A3 batch : Write the report on ‘ Used of the CAD software to design the college E-bike’
- A4 batch : Write the report on ‘ Used of the CAD software by students to design the tractor for tractor design competition’

Thank You For Your Attention