Computer Integrated Manufacturing
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Lecture 06
Computer Graphics (Part 1 of 4)

Welcome to the course on Computer Integrated Manufacturing. Today's topic is going to be Computer Graphics.

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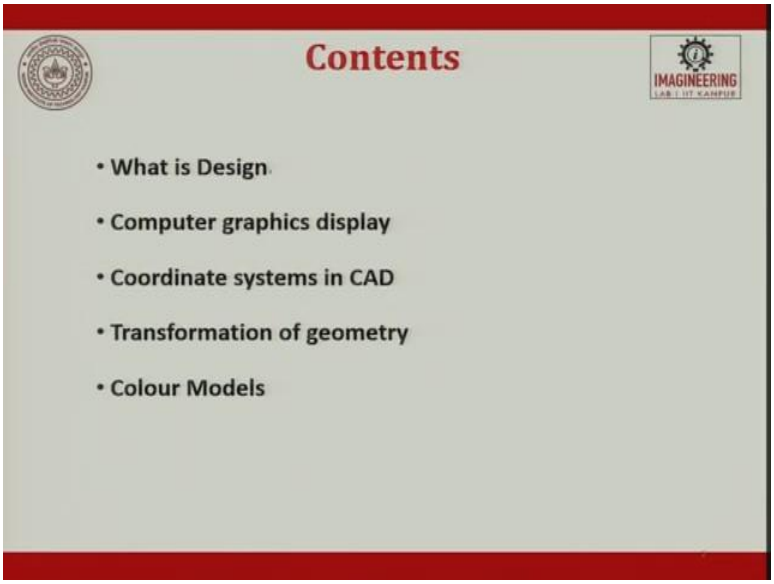

So, we will try to cover today, what is design, then Computer Graphics display, coordinate systems in CAD which is very important because you are trying to transform from one system to the other or within a product from global system to a local system, so that's why coordinate systems is very important. Then we would like to talk about transformations and at the last we will try to talk about color models.

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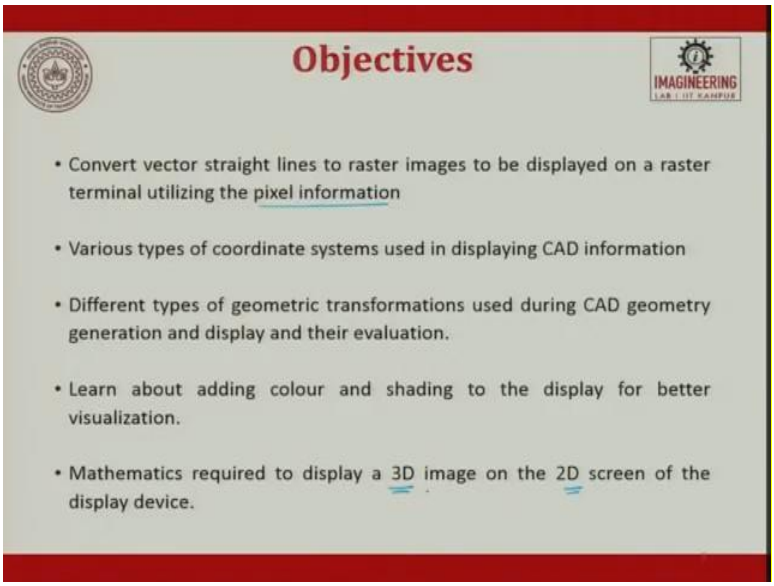

So, the objective of this lecture is going to be, convert vector straight line or raster straight line. When we are trying to draw a straight line in a computer, how does it happen, how does it convert a vector straight line to a raster image to be displayed on the raster terminal utilizing the pixel information. This we will try to understand in this lecture. Then various types of coordinate system as I told you earlier, world coordinate system, user coordinate system, right hand system, left hand system.

Then different types of geometric transformation, when you are trying to move an object, when you are trying to mirror an object, when you are trying to scale an object. So, scale can be uplifting like multiplying it 2 times, 10 times, or it can be reducing it. So, when do we reduce, when we draw an electronic circuit where already the components are of very small feature size, so what we do is we draw it large and then we scale it down.

Whereas, when we have a larger one, larger building and we have to reduce the scale so that you can draw it on a screen, we reduce it, in certain portions where we try to enlarge it. So, both are possible, scaling up and scaling down, mirroring, all these things we will see in the transformations. So, transformation basically we will talk about rotation and linear translations.

Then last, we will learn about the color and shades. We will also try to see how do a 3D image gets stored on a 2D screen. Pretty interesting, when you take a photo, you see a 2D and when you rotate it also you see a 2D, but whereas, when you try to draw a 3 dimensional object in a computer and you have an option of rotating it, you are able to rotate and get a depth effect also. So, that is what is the last part we will try to see.

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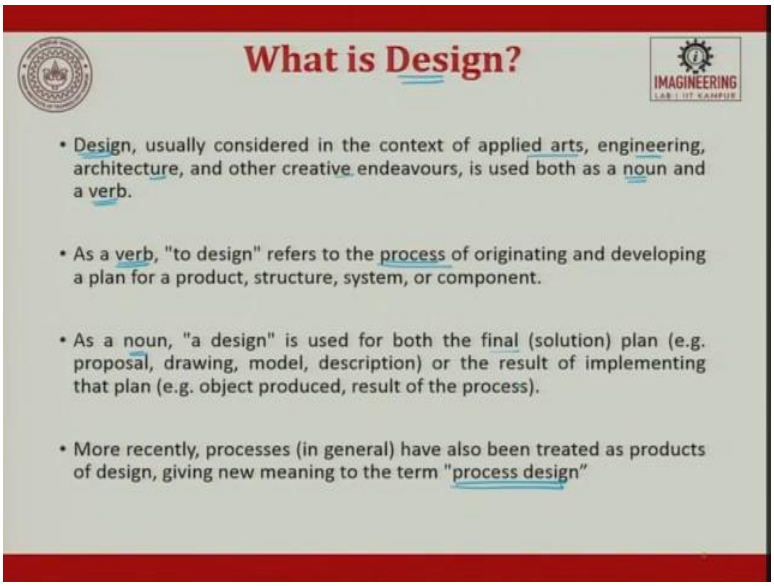

What is design? Is design drafting? So, people just sketch, is that called a design? So, let us see that in detail. Design usually considers in the context of applied arts, engineering, architecture and other creative endeavors, is used both as a noun as well as a verb. It is an action, it is also called as a noun. So, a design is a term which is exhaustively used by arts, engineering people, architect and other creative endeavor people.

As a verb, “to design” refers to the process of originating and developing a plan for a product, structure, system or component. When we talk about design as a verb, it is a process. Actually, design is a process, it is not an event, it is a process. So, wherein which it originates and gets develop a plan for a product, structure, system or component.

When we talk design as a noun, a design is used for both the final solution, final solution planning. For example, proposal, drawing, model, description, or the rest of implementing that plan. So, it can be read like this, as a noun, a design is used for both the final plan or

the result of implementing that plan. Both if we can use it, it' s called as a noun. More recently, processes have also been treated as products of design, giving new meaning to the term process design. So, initially we started with design.

Design, it can be spelt in 2 ways. It can be spelt as verbs, it can be also represented as noun, if it is a verb, it is a process. And then when we, today what has happened, this process they have also started doing for processes of converting raw material into finish product. So now, it has become a process design when we talk about a noun, is used for both the final plan, or for preparing or implementing a final plan. We call it as a design.

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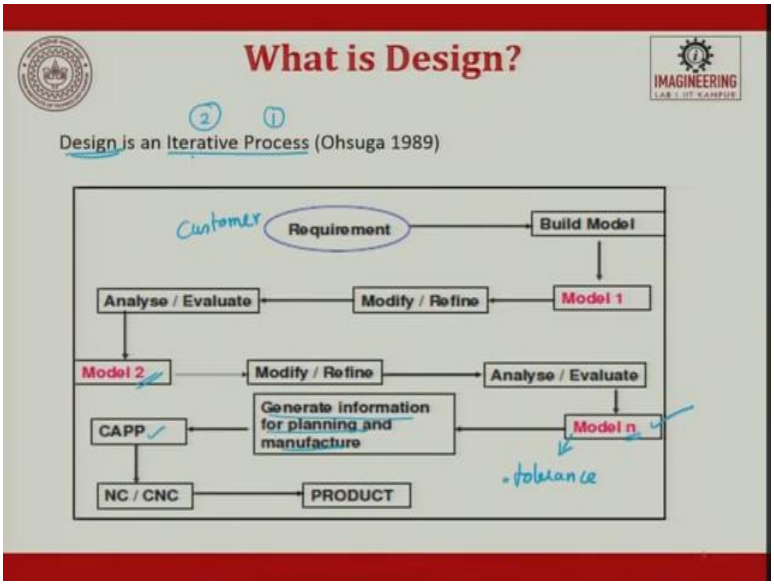

Design, is a iterative process. First word to remember is design is a process, two, is an iterative process. That means to say, there is nothing called a dead end reach in a design process or in a design of a object, design of a product. Every time when you try to design, you will always apply optimization techniques and try to evolve and go towards a better customer satisfaction. So, this entire process, when we call design as a process, the entire process starts with finding out the customer requirement. Moment there is a customer requirement, then you will start building up a model.

After the model is done, it is called as model 1. You have asked it from a customer, the customer has put his requirements and based on that you have developed a model. Now,

you have developed it with the input which is given, but you are not pretty sure whether it has satisfied the customer and mind, friends, that when we try to make a product, it is not only putting customer requirement, it is also to bring surprises to customer requirement.

For example, customer says that it has to be a shirt. And, if you go by fitting of the shirt and developing a product, it is okay. But in that shirt if you can give a color texture, which a customer did not specify but you assume that also, try to develop a model and show it to him. Now what he does is, maybe he did not realize certain requirements, looking at the product he will start refining his requirements, so there is a possibility of modifying and refining of the model whatever you have drawn.

Then you try to do analysis. When we try to do a modifying and refinement at this stage, we try to talk about only from the aesthetics point of view or functional requirements point of view. Now, when we start doing analysis and evaluation of the model 1, we try to evolve and come up with a new design. Now, model 1 gets transformed into model 2. Again, you have not reached the end. So, you will once again show it to the customer and then try to modify and refine your requirements. Then re run the analysis. When we re run the analysis, now what you develop will be model 3.

This step keeps on going back and forth as a cycle. So, the models can lead to n even. Why because, at the design stage is a early failure we face, which is not time consuming and which is not costly. So, people would like to do a thorough design, every time understanding requirements, modeling, developing something and then refining, showing it to the customer and then do.

Once the model is frozen, then the model is transferred for generating information for planning and manufacturing. Product is approved. Now the product has tolerance, which is given, and now we try to make a detail manufacturing drawing.

Till now we are talking about a product 3 dimensional. Now we are trying to talk about, from the 3D converting into 2D, 2D to manufacturing capability for the, or manufacturing details added to it. So, generate information is manufacturing details, so that the planning and manufacturing can happen. From this, you start extracting data which goes for

computer aided process planning, which we discussed in the last lecture. So from there, it is transferred to CNC machines and finally a product comes out. So, this complete step, complete step is called design.

Design is not a single step process, it is not a single step, it is a process. It is an iterative process that means to say, every time it gets refined and refined and improved so that you have a better customer satisfaction.

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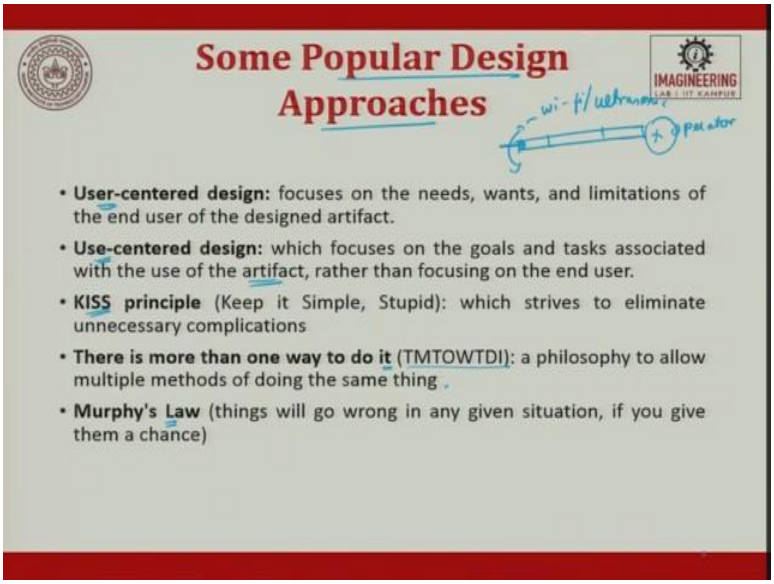

Some popular design approaches which are talked today. One is, use-centered design, here it is user, here it is use. Please distinguish the difference. Then it is KISS principle. Then there is more than one way to do it, so this is the other approach. Then Murphy's Law, which we always talk in terms of computers, so Murphy's Law.

So, these are the different approaches which are available to, some of the approaches which are available today in design. So, we call these approaches as design approaches. User-centered design means focused on the needs, wants and limitations of the end user of the designed artifact. Artifact is a product. What does a customer want from the product?

For example, we all know that there are blind sticks which are getting developed today. These blind sticks will try to guide the blind man, when he walks through it. And many a times what happens, he keeps tapping at the floor, he keep tapping at the floor. So, based

upon the tap sound, he tries to realize that this is the path which he has to too, or he tries to swing his stick left and right and touches the tile which is there so that he realizes, okay, here is a blind man tile guide which is laid, so let me catch it and walk it along.

So today if you go through all, if you go and see in metro cities and wherever they talk about smart cities, there are buildings which are called as inclusive building. They have made sure that a blind man without a guide walks through it. So, here what people have done is, they have started moving forward as well as swinging. But now what has happened, they realize if you keep start swinging, it brings lot of fatigue to the person who operates the stick.

Now, these movement are replaced by using Wi-fi sensors, Wi-fi sensors or ultrasonic sensors. Ultrasonic for sensing at the bottom and Wi-fi to communicate with the existing location where he is, and that in turn connects to the operator and he knows where is he currently located, how far he has to move. This Wi-fi is to tell his current position and movement. Ultrasonic is within the short vicinity whether there is an obstruction or not. So now you see, there is a want which has come from the customer. So, this is getting integrated into a product, so this is called as user-centered design.

The other one is use-centered design, which focuses on the goals and tasks associated with the use of the artifact, rather than focusing on the end user, the use of the artifact. Today what has happened is, people have gone to more towards plastic products, thermoplastic products and then they have started developing so many varieties, because the cost for producing per piece is very less. So, people have started moving out from glass paper weight to polymer paper weights. So, what is a function of the weight, is to hold the papers.

Now when we try to replace it with polymer, the polymer has a lesser weight. And now what people have done is, people have taken that polymer then they have filled sand on top of it. So now you see that the polymer will fly off. Polymer is economical to make and it is also maintenance easy. So now what people have done is converted that polymer, made a small slot, added sand to it and made more user friendly. So, that is use-centered design. Earlier it was man based, now it is use-based.

Then the next one is KISS, Keep It Simple and Stupid, which strives to eliminate unnecessary complications. If you buy, and this is very much used in computers today, in mobile phones today, mobile phone when you take a charger and fix it into the slot of your smartphone, you see that it is possible only through one way and it is as simple as possible. So, that is what is called as KISS. KISS is nothing but Keep It Simple Stupid. So, this is to remove all unnecessary complications.

Then next one is, there is more than one way to do it. Suppose, you have already reached a solution and you think that this is the ultimate solution. Now, it is also required for you to look little far away from the product through all your passion and say, think, is there any other way of solving it? For example, in math, when you try to solve in the examination, there are several logics which you follow to go towards the answer. So generally, what we think, there is only a unique way of going towards the answer, not necessary.

So, that is what is told in this concept. There is more than one way to do it, a philosophy to allow multiple methods of doing the same thing. So what happens is, when you try to solve the same problem through the other routes, you try to figure out simpler steps and you also try to come out with error free solving it. So, that is what is used in this approach. There is more than one way to do it. And the last approach is Murphy's approach. There will, things will go wrong in any given situation, if you give them a chance. This is Murphy's Law.

So here again, it is overlapping with the KISS example, try to make all the assemblies foolproof. For example, you buy a RAM today if you want to introduce it inside a slot, it will not allow you to press in the wrong direction. If you apply lot of force, even the RAM slots will get broken. So here, this tries to make sure that whatever assembly is done, it is foolproof. These are some of the approaches which are followed in design today. When you take a product to convert it into a design, we use these approaches.

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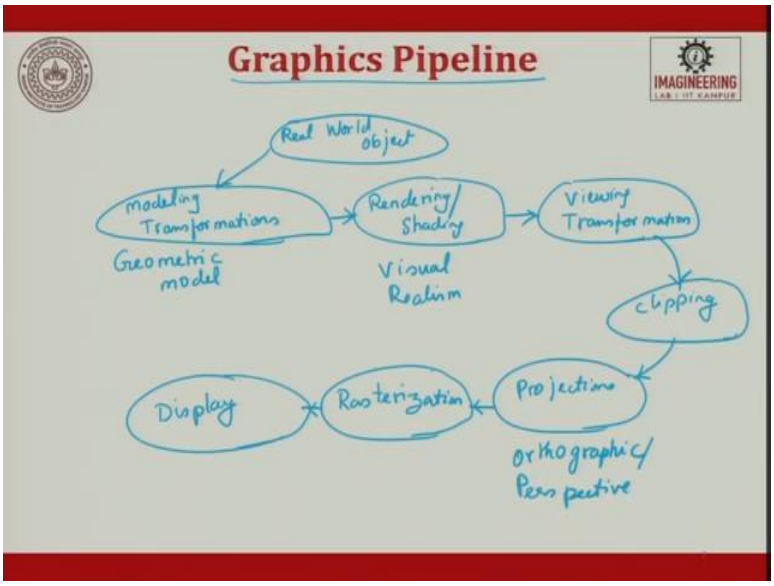

So, when we talk about graphic pipeline, so it happens like this. First you have real world object, which will try to give lead towards model, modeling and transformation, then it leads to rendering slash shading. You have a product, you are trying to develop the product, now you have to give a texture to the product, then we have a viewing transformation. Then you start giving editing features on the developed one, so that is nothing but clipping. From the clipping, what you get is the projections.

So, when you try to view it or rotate it, how are you able to do, then it is going to be rasterization. How are you going to represent it on a screen, rasterization. And then finally, you will see the display on the screen. So here we will talk about geometric modeling, wherein which we do, see when you try to draw a line, move a line, when we try to rotate the object, when we try to, I told you, crimping or when we try to scale it up, when we try to mirror it, so all these things come in geometric modeling and here it is more towards visual realization.

And here when we talk about, we talk about orthographic or perspective viewing. So, this is how a graphic principle or graphic pipeline is followed. Starts from real world, you do transformation that means to say you are developing object, you are trying to do a texture, outer surface, then we are trying to view so that you get the depth information, unnecessary things are clipped, so then you try to look for orthographic projection or perspective. Then

what happens is whatever you have developed has to be projected on to the screen, so it is rasterization and finally what you get is the display of it.

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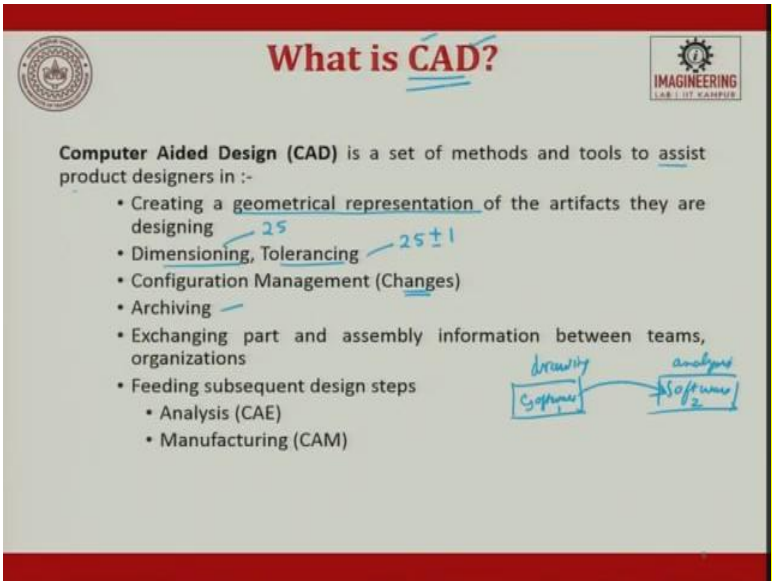

What is CAD? So, design we saw and now let us see what is CAD. CAD is nothing but Computer Aided Design. It is a set of methods and tools, to assist product designer in creating a geometrical representation of the artifact, artifact is nothing but a product, they are designing. It is used to create a geometric representation. Next for the developed geometry, you are trying to give dimension and tolerance. What is dimension? 25 is the dimension. What is tolerance? 25 plus or minus 1.

So, why is tolerance given? Tolerance is given because when we are trying to machine, there is always a possibility of variation from product to product or part to part. So now, what we do is we legalize and we also make sure that while assembly we do not have any problem. Wherever a part gets assembled, tolerancing becomes very important.

Next one is, configuration management. So, these are nothing but the changes whatever you want to do, so that is possible in CAD. Next is archiving, you can develop something, store something and pull out and then re edit it to go towards the final product, that is archiving. Archiving is nothing but storing, exchanging part and assembly information between teams and organization.

For example, let us assume you have a software, software 1, you have a software 2. So, this first software is for drawing, this is for drawing and this is for analysis. So, you are supposed to transfer the data from one software to the other software for doing further thing. So here exchange of part, assembly information between teams or organization can happen.

Next is feeding subsequent design steps like analysis and manufacturing, all are part of the assistance to product designer. So, all these operations, set of methods can be done using CAD.

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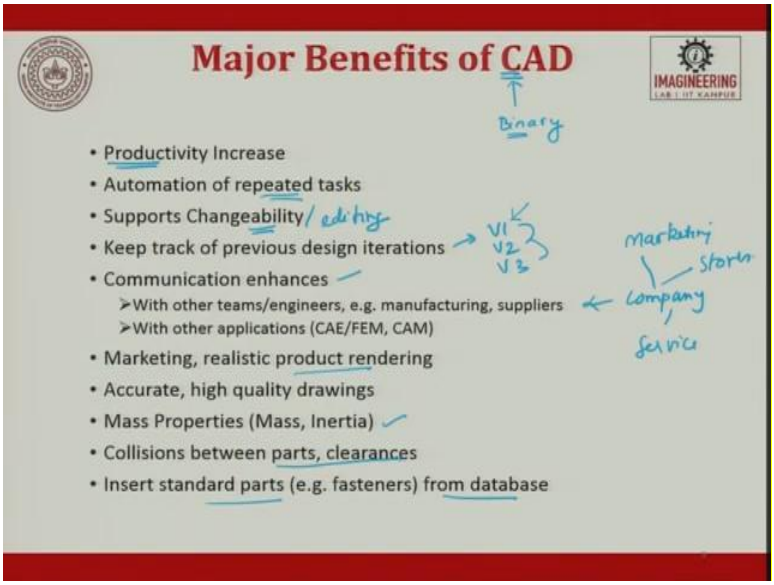

What are the major benefits of CAD? The major benefits of CAD is productivity enhancement. All these things could happen because we use computer. What is a big thing about computer, computer uses binary. So now, the language what it talks is all binary. Binary, you will have a superset something writing into several applications, but it is all in binary informations.

So, when you have to transfer informations, exchange, edit, you all have only unique, that is binary, 1s and 0s. So because you use that, now the productivity is started increasing in the factory.

Next one is automation of repetitive tasks can be done using CAD. For example, you have already done, you have kept it in archive, if you are doing it manually you have to redraw, but whereas in computer in just click of a button you pull the drawing once again and start working on it.

Support changeability, changeability or editing, whatever, to the requirements. Keep track of previous design iterations. For example, version 1, version 2, version 3, all these things. So, when you start scoring it in different versions, so then you will see, the first day why did I come to this process and from here what new information I had, I went to this, then to this. So, this will try to give you the evolution of a product over a period of time, which will try to guide you through in the future.

Then communication exchange, which I already talked, within other teams, within other application. So, then teams here within a company, you are talking within a company, you are talking with say marketing people, you are trying to talk about service people. So, everywhere you are able to communicate because the drawing is the same. Then you will also try to talk to stores people.

So, market realization product and realistic product rendering. Suppose, you try to virtually develop a product and you are able to show it, show the texture, the color, what is going to or what are you going to give to a product, so this also can be shown if you use the benefit of CAD, otherwise it becomes very difficult. Initial days what they used to do is, they used to make the complete prototype of the product in clay and then they used to give colors to it. They, it is a very tough job.

Then accurate and high quality drawings, then apart from the all these things, when you have a computer drawing made so you can easily do all the calculations, whatever you want. Such as like, what is the surface area, what is the volume, what is the density, what is the mass, you can all, what is the inertia required, all these things you are able to get because you are using CAD.

Then you can also use it for analysis, static analysis, dynamic analysis, you can do and try to see the response. You can also try to use a CAD drawing for simulation. Simulate it for

extreme conditions and see how does your product respond to real time. Then knowing that, we can start going back and then quickly changing those portions where corrections have to be made and reiterate. So, this will try to give you a faster lead towards developing products.

Then collision between parts and clearance, this is like simulation what we talked about. Then, insert standard parts from the database. So here what happens, while drawing, machine drawing, where you draw several parts, there will be several screws and nuts and bolts which are common. So, every time rather than calling it back, you put it in a library function, pull it from the library function and use it in your drawing. So, this will try to increase the productivity. So, all these things are the benefits which are achievable or enjoyed while using CAD.

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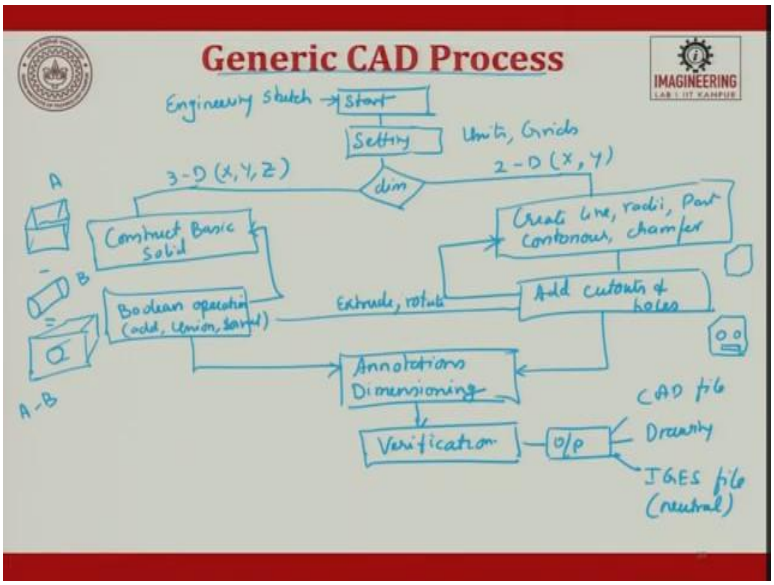

So, let us try to see in a generic CAD process, what are all the steps involved. So first one is, start. So here, you are trying to draw the engineering sketch then we try to do setting. In the setting what we do is, we try to give units, we try to give grids. So, snap on, snap off, all these things. Then we try to give dimensions, then it can be divided into 2 parts, this is 2D that means to say X and Y information.

Here it is going to be 3D, we give X, Y and Z information. And then what we do is, we try to create unit 2, 2 Dimension X and Y, we try to create line, radii, part contour and we also try to give chamfer. So, all these things are done here.

When you try to go here, we try to use construct basic solids, later we will see construct in solid geometries, basic solids. The next step here is, we try to add cutouts and holes in the drawn object. So, then we try to go back, so we can then extrude, rotate. So here, what we do is we try to use Boolean operation. What are Boolean operations? A union B, A intersection B, A subtract B, whatever, invert. So, all these things are Boolean operations.

So, this is extrude, so you try to go back and then develop it and then for what happens is, let it be 2D or 3D, then they come towards annotation, annotating or annotations and dimensioning. Finally, we try to verify, verification and then we try to get the output. So, output will be a CAD file. You will get a drawing, you will get a IGES file, these files are called as neutral files for communicating between two different things.

Suppose here, let me give you an example. Suppose, you have a cube which is made and then you are trying to subtract a cylinder, so what you will get is, you will get a object like this. So, this is a cube A, this is B, this is A minus B. When you look into here, so what we are trying to say is chamfer radius, you get the object here whatever I said. And then what we do is, we try to cutout and then we try to develop it. So here, it is 2D and here it is 3D.

So, this is engineering sketch which we do and this is the generic CAD process, you start, you do settings, then you put then you write dimensions, then no, you write dim. So, this is going to be 3D, dimensions here is 3D, 2D. So, in 3D you construct a solid, then you construct a solid which you want to subtract, then you subtract these to do a Boolean operation, you get whatever you want. And then you annotate, put dimensions, verify output.

When you go through this, create line, circle, then you can extrude that line and circle and then you subtract, get this annotation and then get the verification. So, this is the process of generic CAD. Thank you very much.