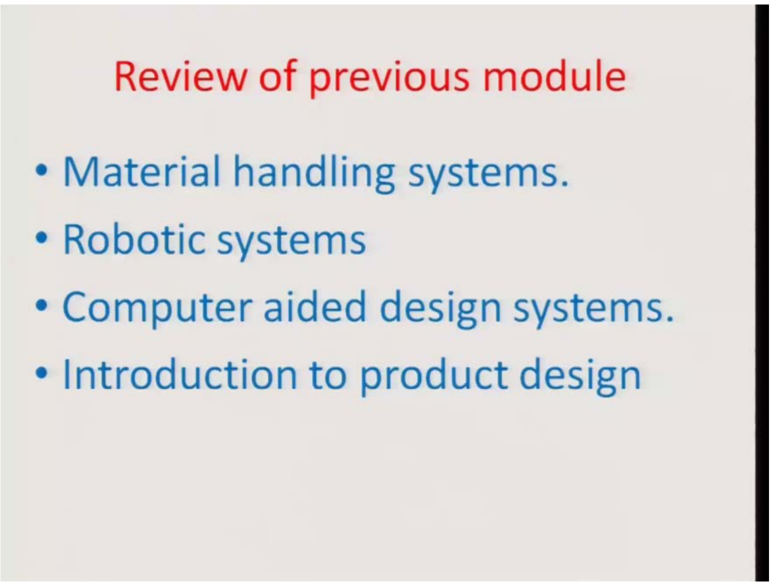
Manufacturing Systems Technology

Prof. Shantanu Bhattacharya
Department of Mechanical Engineering and
Departmentof Industrial and Production Engineering
Indian Institute of Technology, Kanpur

Module - 01
Lecture–04

Welcome to this module 4 on Manufacturing Systems Technology, a brief recap of what we did in the last module.

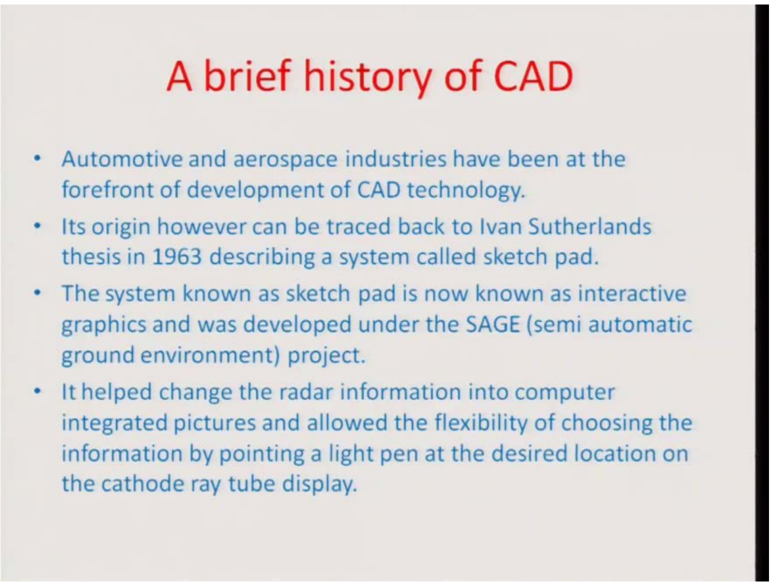
(Refer Slide Time: 00:19)



We talked about certain material handling systems, particularly automated material handling systems of, which rang very well of the modern manufacturing processes.We also discussed certain robotics systems and how the field of robotics has emerged and in fact, details are reserved for later on module.And then, we started discussing about the introduction to product design process, which is a six step process, where we particularly discussed about, what would be the aspirations when you want to design, let us say a notebook type computer, something like that.

And then,in context of that we also made a mention of computer aided design systems,which would be helping to generate more of visualization, more of clarityin the thoughts along the design refinement processes of a product.

(Refer Slide Time: 01:06)

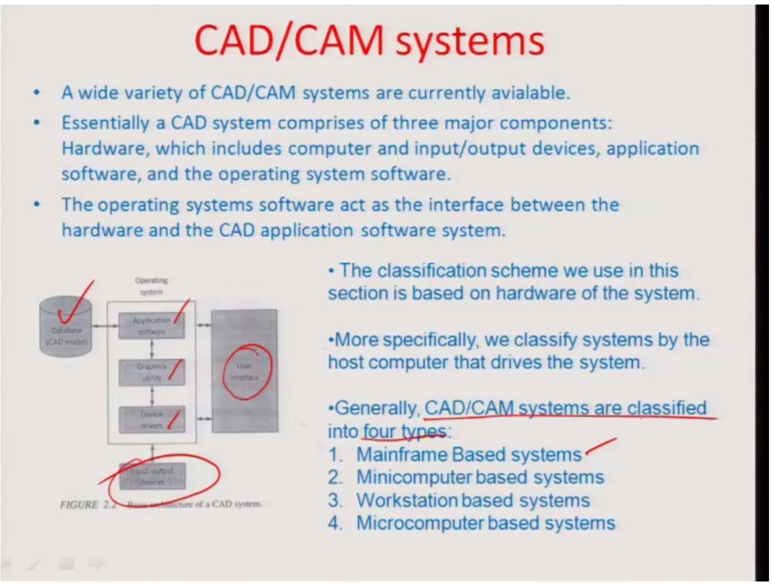


Now, if you look at a brief history of how the computer aided design has emerged, in fact, the CAD technology has been necessitated more,because of the automotive and the aerospace industries.These are the mostly sort of, you know the heaviest users you would say of,so called computer aided design technology. And if you really look at how CAD had evolved the basic foot step in the area of computer aided designing was, if you look at the you know the history there is a very famous thesis by Ivan Sutherland in 1963, which talks about the basic sketch pad.

So, the sketch pad is now known as the interactive graphics,which was developed under the SAGE project,which is Semi Automatic Ground Environment project. And the idea was that if you have a radar map coming out of an aerospace or a airplane, can I actually pinpoint to a small zone of the map and blow it updo all the kind of translations, which could be there. So, that I could actually a certain target, that we would have from that radar map clearly pointed out on the screen.

So, if it is about a pen, an interactive infrared pen, which would actually touch up on the various areas of the screens and would create impressions within such a radar map.So,this was the historically the first step towards, what you know as the modern day computer aided design process.

(Refer Slide Time: 02:33)



And ever sincethen, thevariety of CAD/CAM systems have evolved,currently there are wide variety of such systems.And if you look at really, what are the different components of such CAD systems so; obviously, the three major components are the hardware,which is the tool which does the computation,the backend computation behind the visual display, the magnificent visual display that you are seeing at the front end and it includes computer input output devices and application software’s and operating system software’s.

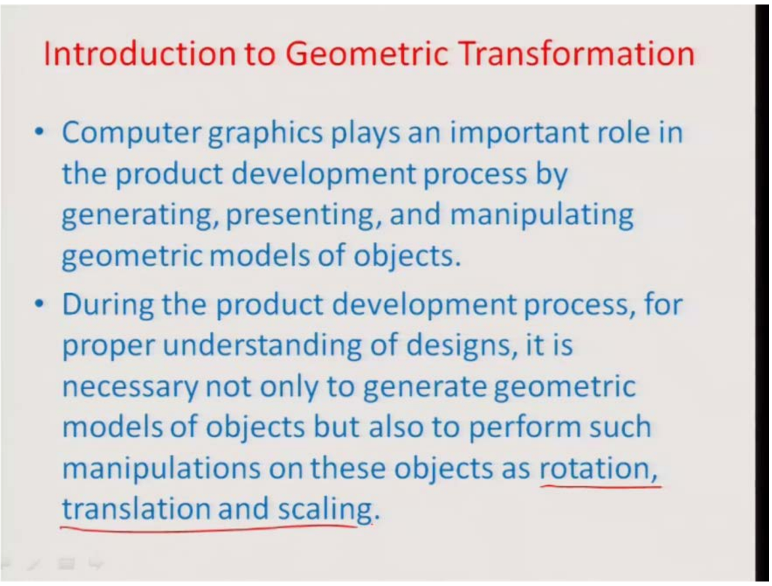
So, these are the major components of any computer aided design system and you can see here for example, in this sketch that there is a database, which the CAD starts with,where the CAD model is really stored or it can be modified or it can be uploaded. The operating system completes sort of,it comprises application software.The graphics utility, the device drives, which would be able to sort of communicate with a variety of input output devices.Output devices could be something like printers or plotters or whatever you have plotted on a CAD package can be printed successfully.

The input devices can be something, where from which you can machine read the CAD data from a storage unit, you know.Something like a, let us say hard drive or something, where there is a temporary storage, which can be directly mapped etcetera.And;

obviously, there has to be a user interface, which would be able to definethe muness in the various modalities of the CAD and try to also make a new designs etcetera through this user interface.

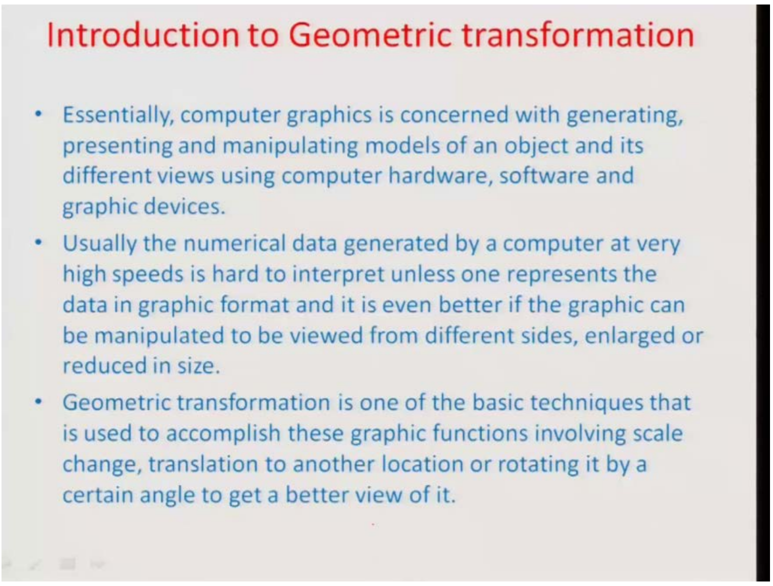
So, currently the CAD/CAM systems are now classified into four main types.One is called the mainframe based system,the mini computer based,the work station based and also finally, the micro computer based system.So, the main important aspect here that person from technology background should know is that,behind all these socalled visualization there is a huge amount of geometrical transformation based calculations, which are being computed by the computer every secondand you need to know about such transformations and how geometrically you can manipulate an object. So, that you can magnify it,rotate it, translate it, soon and soforth.

(Refer Slide Time: 05:01)

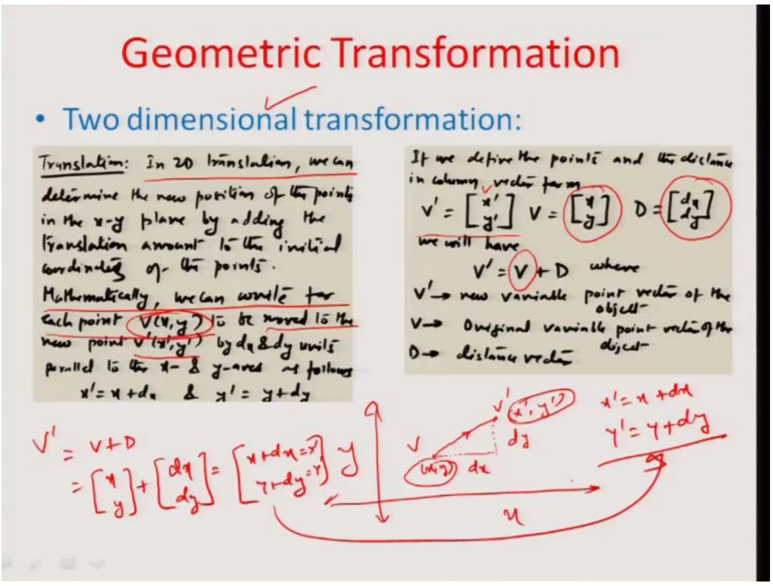


So, let us look at some of those geometrical transformations and; obviously, the need fortranslation ortransformation is to sort of calculate, when you perform a certain function on the object in question such as rotation, translation, scaling, soon and soforth.

(Refer Slide Time: 05:14)



(Refer Slide Time: 05:15)



And let us look at independently now, some of the things related to let say two dimensional translation, that we are talking about, let us say a point in space, which has, which is in the xy coordinate system. So, you have one x value and one y value and we typically call this plane with a x and y axis as a two dimensional plane and there is a point, which is there on the two dimensional plane, which we want to translate.And we want to see if there exists some kind of a universal way by which,we can do this translation, which is easy for a computer system to understand.

So, at the outside I would like to tell you that you know all the data management inside a computer system is becomes easier automatically,when you can identifythe location of the data in a big tabular kind of manner. So, you can give the row number and the column number for that particular data and it is very easy for a computer to identify and read that data, once the row number and column number is specified and also it is specified that how to approach that row number and column number.

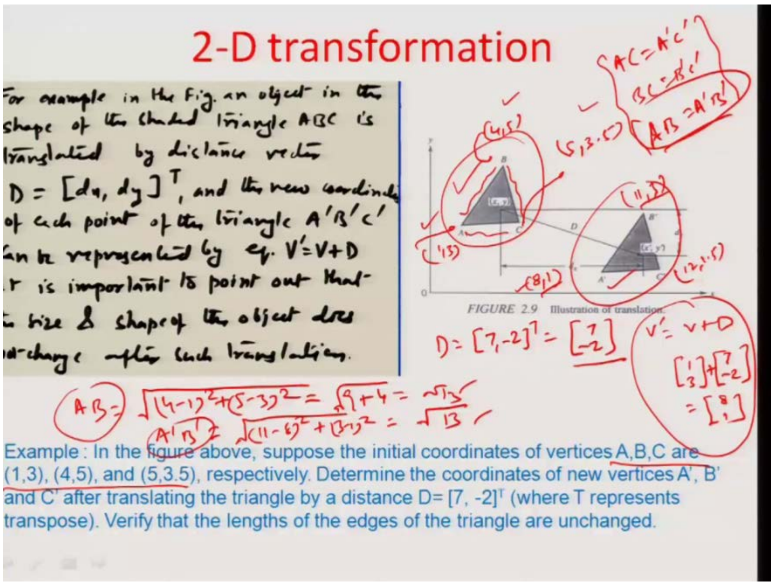
And the best way to handle such system is by giving matrices,where would you would actually have all the data packaged in forms of matrices etcetera. And therefore, we would like to emerge a system, where such row number column number based classification is universal across all the different geometrical transformation processes that we would like to look at. So, let us say in this two dimensional translation there is a point which it is you know mathematically defined as vxy.

So, this is that point, where you have a x and y coordinate and you want to movethis to a new point v dash x dash y dash.And further you know that in a two dimensional coordinate plane like this x and y from the point v, which comprises x and y you are moving exactly a certain distance in the x direction and a certain distance in the y direction, let us say dx distance and dy distance. So, that finally, you are this point x dash y dash; obviously, x dash is equal to x plus dx and y dash is equal to y plus dy.

So, the way to write this whole you know transformation and now linearly transforming this point from v to v dash by taking this point literally from v to v dash whereas, x dash y dash are the new coordinates and x, y were the old coordinates. So, you can actually write it in matrix form as v dash, which is a matrix x dash y dashequal toa matrix v, which is xy and plus a matrix d, which is the distance matrix, which is dx plus dy.

Obviously, what it would rule is that v dash equal to v plus d means there it is equal to xy plus a matrix dx, dy, which would be x plus dx and y plus dy,which is actually nothing but,x dash and y dash as was being seen here. So, that is how we actually geometrically transform a certain point from one place to another on a two dimensional plane.

(Refer Slide Time: 08:40)



So, can we do the same thing for a three dimensional figure is the major question for example, two dimensional figure for example, let us say instead of one point now we have a triangle,which are defined by three points and interconnected though three different lines and we want to move out this triangle as is from point A, B, Cto the point A dash B dash C dash and we want to see whether the linear transformation that has been applied earlier holds true in this particular case.

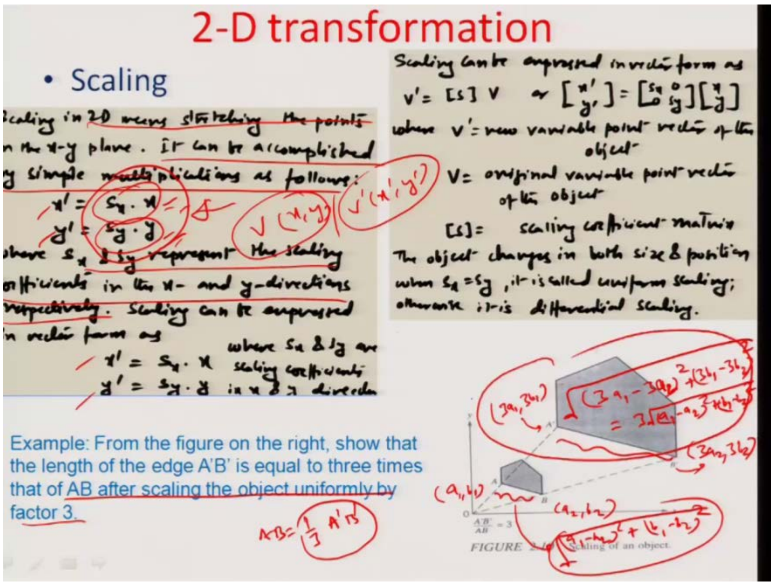
So, let us say in this particular figure here you have coordinate x of points A, B and C defines as 1, 3. So, that is the coordinate of A.45 that is the coordinate of Band 0.53.5 ; that is the coordinate of C.And now, you are basically translating this triangle to the position A dash B dash C dash by a distance matrix,which is actually 7 minus 2 trans; obviously, it means that you can write it as a transformed matrix 7 minus 2 like this.

So, the point A dash as per the equation v plus d equal to v dash becomes equal to 8 and 1. Obviously, the v for the point A becomes the location coordinate 1, 3 and the distance transpose matrix becomes 7 minus 2, sothis becomes 8 and 1,which I have written it here. And in a similar capacity we can write the d dash as 11, 3and the C dash as 12 and 1.5. So, we can actually look at all these coordinates and see for example, on the lens side of BC or ACand in this transformation was true if you assume that this transformation is true,then the lens AC should be equal to A dash C dash BC should be equal to B dash C dash and AB should be equal to A dash B dash.

In other words, even though there is a linear transformation the triangle will not change in shape or size all the sides are going to be in the similar length domain. So, let us look at that aspect here for example, if I wanted to calculate the length AB here this would actually result in 4 minus 1 square plus 5 minus 3 square, which is actually equal to 9 plus 4 root, which is root of 13.If I look at A dash B dash and take the new coordinates 8, 1 and 11, 3 we also have the same root of 11 minus 8 square plus 3 minus 1 square, which is root of 13 again.

So, therefore, the lengths are really not changing and therefore, there is no change in scale and the triangle is being linearly moved from place 1 to place 2just by following the simple v dash equal to v plus d transformation matrix.

(Refer Slide Time: 11:47)



You can look at all the different other lengths for example, BC comes out to be 3.25B dash C dash comes out to be 3.25 CA and C dash D dash comes out to be 16.25 and 16.25, which means that the transformation is working uniformly for a homogenous transformation of a pointon a two dimensional plane.Let us talk about scaling a little bit, soif we wanted to scale an object or scale a particular structure to two times or three times the size,what is the modality which is involved in that.

So, let us say again we compare a two dimensional plane,where there is a certain orbit structure,where you want to magnify that structure into a 3 times or 4 times larger object again on the same two dimensional plane. So, it can be accomplished by simple multiplicationsand the transformation matrix that can be used is that if there is a point xy on, let us say a point v in certain two dimensional plane and you want to magnify it and transfer to another point x dash y dash point means that you know it cannot really magnify a point.

But,you can magnify an array of points an array of points can be something like, let us say this pentagon here,which talks about a length AB for example, in the lower baseand if you magnify this by 5 times the idea is this length A dash B dash,which is a spacing between these two points should be exactly five times the value of the AB that we are considering here.So, here for example, x dash and y dash the new coordinate systems can be envisioned as sx x and sy y,where sx and sy represents the scaling coefficients in the x and y directions respectively and scaling can be expressed in the form of x dash is equal to sx x and y dash equal to sy y.

So; obviously, if I wanted to represent in terms of a simpler matrix I would write v dash to be equal to some matrix s times of v where this s can be represented as s x is 0. Now, this is no longer you know a one cross two matrix it is actually a two cross two matrix, which emerges, which we talk about s x 0 ands 0 sy and x and y, let us look at if we do the product between these two matrices whether we are able to get the x dash and y dash we already know that the x dash and y dash is actually represented here as sx x and sy y at this particular zone here.

So, if I just product or if I just do the multiplication between these two matrices the there would be an emergence of this x dash and y dash the first term would be s x x plus 0times y and; obviously, the second term would be 0 x plus sy times of y. So, if we finally, calculate it is sx times of x and sy times of y that we are considering to be x dash and y dash as is represented here.

So, therefore, we can see that the whole point you know v dash is not to be sx x and sy yas predicted here in the earlier transformation through this matrix method. Now, you just look at this example here that there is a length AB, which needs to be magnified to A dash B dash and whether the same you know theory can be applied to these two points, sothat the scaling of this line can be exactly three times. So, suppose you wanted we have coordinates of point A here as A 1, B 1 and the coordinates of point B as A 2, B 2and we wanted to map this to three times scalingas three here.

Obviously, from the expression, which is given here magnification factor time x would be the new coordinate. So, we have 3A1 and 3B1 as the new coordinates of A dash and similarly,3A2 and 3B2 as the new coordinate of B dash.So, you can see here that the length ABis exactly equal to one third of the lengthA dash B dash you know if I calculate the length A dash B dash here, which is three times of A1 minus three times of B1whole square plus A2 whole square plus three times of B1 minus 3 times of B2 whole square whole under the rootthis becomes exactly three times of A1 minus A2 square plus B1 minus B2 square.

And the length AB was earlier represented as A1minus A2 square plus B1 minus B2 square whole under the root.Therefore, this exactly AB length is a third of the a dash b dash length which is given in this calculation here. So, this is how you can see that even if you are magnifying an object by three times and you put the geometrical transformation simple sx x and sx y as the magnification factor times the coordinate the overall length is getting changed by almost three times,because of that magnification.

So, in the next module we would also like to study rotation of anobjectand then finally, translation and then,we would like to do a very complex geometrical transformation on the three dimensional plane of an object.

Thank you