Technical Arts 101
Prof. Anupam Saxena
Department of Mechanical Engineering
Indian Institute of Technology, Kanpur

Lecture - 27
TA 101
Think and Analyze

A circle break it down to 2 parts rotate this guy about the zee axis, rotate this guy about the y axis or x axis combine them together U C. This is with regard to as much as drawing can do. But there is a very interesting philosophy behind this; there are a bunch of C words, that if you understand. And if you think and analyze about those c words, you will be great throughout your life, from now till the age you retired and beyond. This was what my last lecture was going to be about it is still on if you guys are interested, I will have to figure out a time. It is got nothing to do with the drawing that we are learning, but since this course is about thinking and analyzing. I thought it may be a nice idea for me to introduce to you those c words that we can cogitate upon C word a cogitate upon, but that is for later, not now...

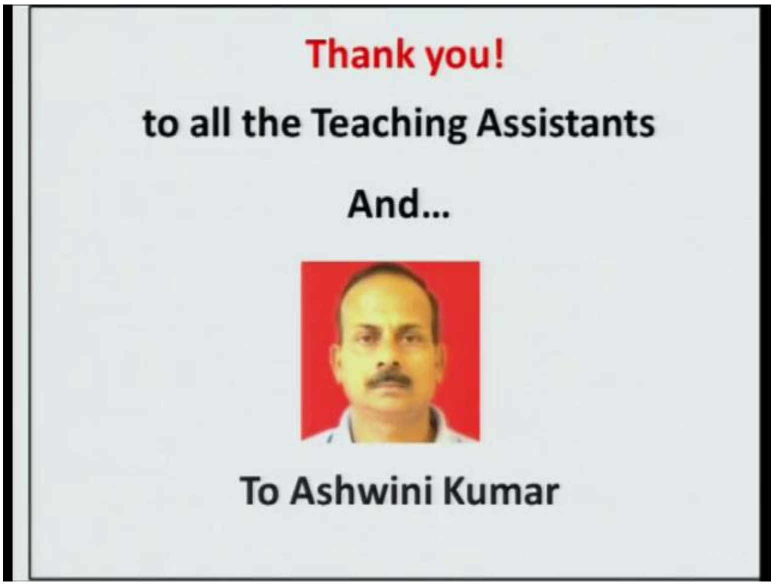
(Refer Slide Time: 02:42)

I will start by saying thank you; this is my penultimate lecture twenty fifth. Officially my last lecture is on Thursday this week. So, I will start by saying thank you to all who have helped all of us in making us you, including me think and analyze together. First the tutors, Prof Vinod Tare, so I will start with civil engineering. Frankly, I am not really sure, how effective the slides have been on my webpage in making you guys learn. So, a little feedback were they effective, were they not effective, were they good, were they useful, were they not useful. There is a story back in 2003, 2004 when you are still in grade school; Prof Vinod Tare he was standing here, and I was sitting over there as a tutor. And the idea that I should be using animations and trying to explain things to you actually came from him.

So, he used animations in his presentations, I was very impressed with. And I thought maybe I will continue with that idea, he was a 5 star instructor, he is still a 5 star instructor. So, I am not really sure; if I will still be able to you know compare myself with him, but the idea of using animations in slides making you guys follow and teach actually came from him. So, he deserves another round of applause.

Prof Purnendu Bose, Tarun Gupta Prof Tarun Gupta, Prof Rajiv Sinha, Prof Javed Malik, Riya George. From aeronautical we have Bhardwaj, and we have Shantanu. From mechanical we have Prof N N Kishore sitting right there he is going to be teaching this course in the coming semester. And Prof Kishore if I can see you thank you very much, your feedback was wonderful. And your idea about the three point perspective was absolutely fantastic. So, I enjoyed it, I learnt it, thank you. Prof Ashish Dutta ((Refer Time: 05:32)), Prof Basant Lal Sharma, and Shakti Singh Gupta. I do not have the names of all the teaching assistants of this time, but they work there in the fore ground not here.

(Refer Slide Time: 06:07)



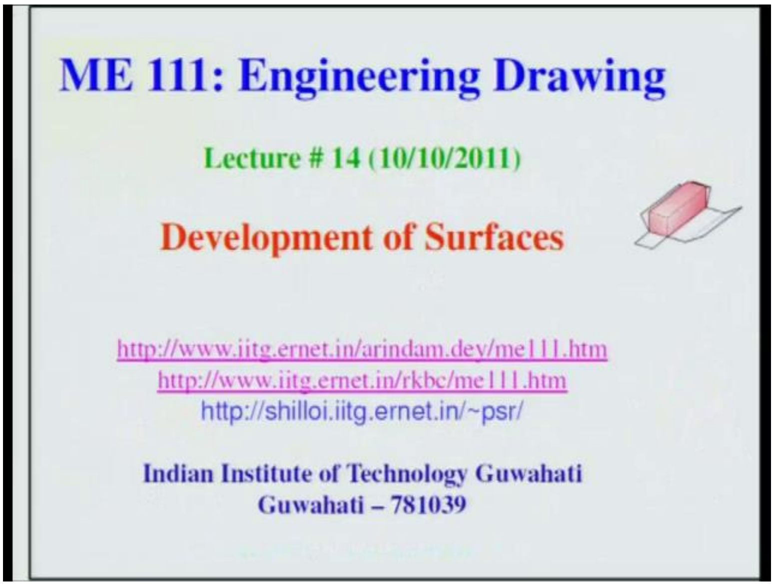
But in the labs and they were there for great help to you. So, thank you to all the teaching assistants. And a person you have not seen, or you may not have seen, so he is a person who has been doing all these work in the background preparing models, preparing auto cab, stuff and you know helping me with lot of things Ashwini Kumar.

(Refer Slide Time: 06:50)

Alright, so we will start with the new topic; development of surfaces. You know I am exhibiting a few solids here; some pyramid well, 1 2 3 4 5 6 hexagonal pyramid which is truncated by a plane. Another something very similar; a skew pyramid here, skew tetrahedral here, this is the hexagonal pyramid again regular hexagonal pyramid. This is have a nice structure, so which is again I think a hexagonal pyramid. But it has a cylindrical void, and it has been truncated by a plane. Another something very similar; so what I will do is; I will pass these things on to you can take a careful look and return them back to me, do not take it to your hostel rooms. But what is very interesting about all the solids is; they have been made by paper. And importantly a single piece of paper, ok.

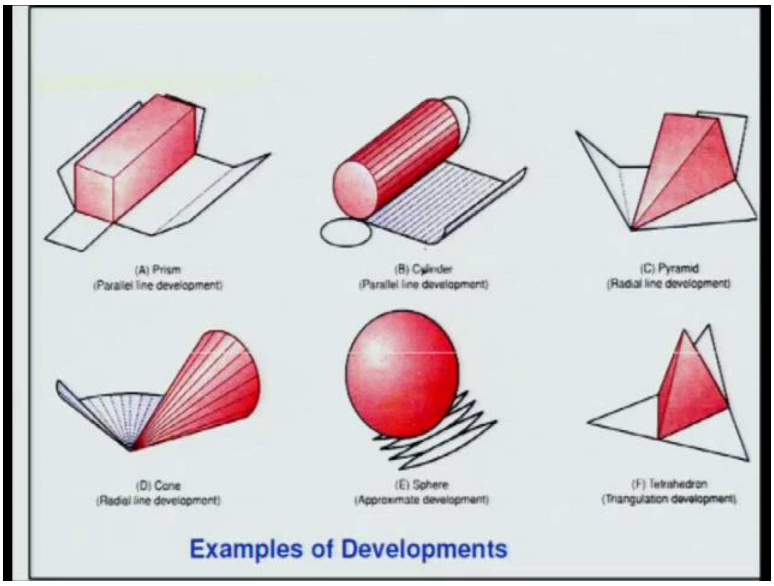
Now, let me revert this question, and ask you this; how would you want to prepare this, so that you get the solid. How would you want to prepare that corresponding piece of paper, so that you get the solid, and this what this lecture is about. Yeah, pass it on do not do not do not keep the solid with you, can you come from somewhere there; anybody, any body do you know that north west is, do you know that north west university is you want still anybody.

(Refer Slide Time: 09:27)



So here we go penultimate lecture; you know I was asking god as to whether it has whether he has, or she has many examples on development of solids. And I came across this nice setup, nice p d f from I guess I T Guwahati I well Arindam Dey is a name taught this, and I liked few picture in this.

(Refer Slide Time: 09: 51)



And these are the pictures. So, what you see is; a box, or a block, a cylinder, a tetrahedron, a cone, a sphere. And well this is the tetrahedron; this is pretty much like a pyramid, yeah. And what you also see is that; they may have been made by paper, and how would you want to kind of unfold the paper, so that you can lay it down flat on a plane. So, perhaps you can cut one of the edges, you can make one cut over here, you can make one cut over here, another cut over here, open up and lay it down on a plane. And once you fold them back, you would get these cuboids for example; same thing with the cylinder. You know so cut this face; cut this face apart you know and make a cut along this direction lay it down. So, essentially the idea is that all of the solids except for perhaps sphere, they have been made by a single piece of paper. And the question again is; how would you want to prepare that piece of paper, so that you can get the solids back.

Alright, so this is quite straight forward right; the unfolding quite straight forward, the unfolding over here is quite straight forward. So, the method is the parallel line development; you know lay it open, cut and lay it open, parallel line development this is pretty much like a radial line development. Pretty much like you know for example; when you cut the pyramid, you open up so I speak a sector, not a rectangular piece of paper but a sector. Same goes with the cone, and with the tetrahedron, you open up this piece of paper into triangles, ok. So, just an example so example 1, 2, 3, 4 and 5; they happen to be examples, where you prepare your piece of paper in such a way that you get the exact solid back. Yeah, this one is like an approximate example, will talk about that.

So, certain developments are exact, certain developments are approximate. So, except for this example; all the other developments are exact, this one is approximate. And this one is this point seems to be important. So, for example; if you have a little void here on the surface, or may be perhaps a void here, or a void here, or any feature, when you are opening up that corresponding piece of paper, what do you expect? Should that feature be in, should the feature be in true dimensions, or it should be in some sort of you know untrue dimensions you speak. Or, projected dimensions; what do you expect? True dimensions?

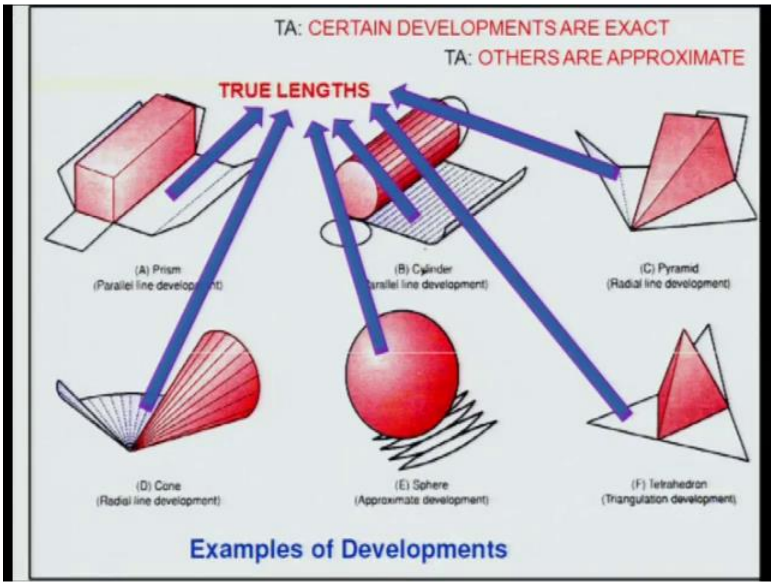
Student: Yes.

Everybody?

Student: Yes.

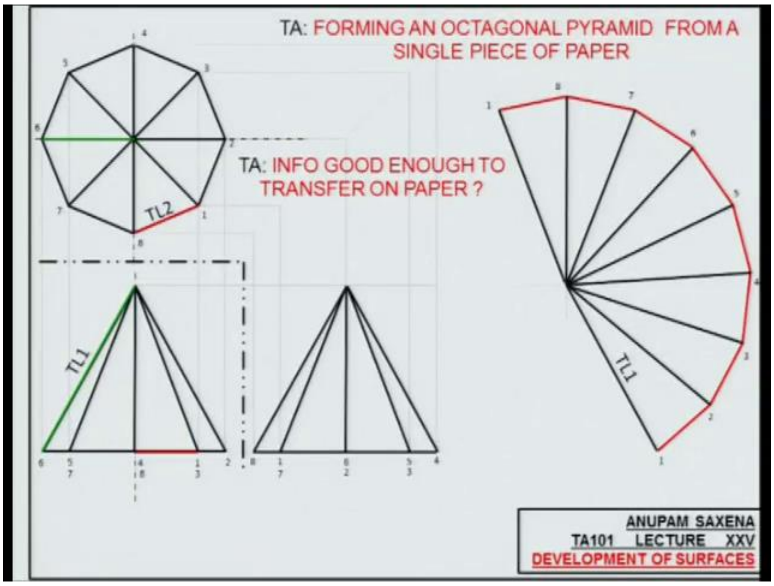
This is what the intent is.

(Refer Slide Time: 13:06)



So, if you look at these surfaces, all features on these surfaces they have to be in the true dimension. And that is the point that you have to keep in mind, when you are developing a solid or developing a surface true lengths or true shapes.

(Refer Slide Time: 13:25)



So this is an octagonal pyramid; let us try to lay it open on a plane. You have given, you have been given 3 views; the front view, the top view, the right view. Well, the question is to form an octagonal pyramid from a single piece of paper. So, we have to figure out how to make cuts on that singe piece of paper, ok. Now, look at this length this horizontal length in green here, what is the corresponding projection? This guy here, yeah. Now, what do you have to say about this length? Is this length in true dimensions, why is that?

Student: ((Refer Time: 14:17))

Because the corresponding projection is parallel to the hinge in one of the views, right. So, this projection is parallel to the hinge in one of the views and therefore, this one is in true length. So, I will call it T L 1, ok. Look at this projection over here in red, and look at the corresponding projection in the top view; is this projection in true length?

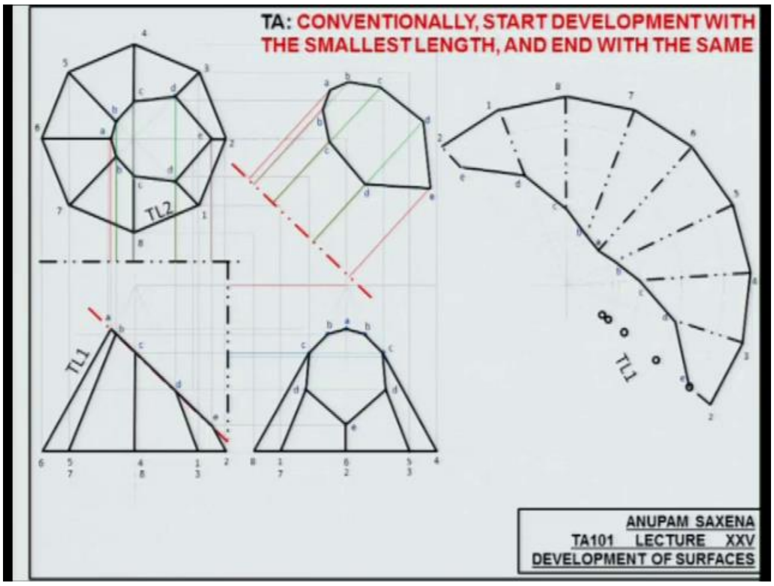
Student: Yes sir.

Again, the same principle, so this projection here is parallel to the hinge line in this view. And therefore; this one should be in true length. So, I will call it T L 2, the entire thing that you have to keep in mind is to figure out, or keep figuring out the true lengths, ok. Is this information good enough for you to work with a paper on plane. Is it information good enough for you to transfer the entire information that this surface has this solid has, on a single piece of paper, yes alright, let us see. So, you have this true length T L 1 alright. Taking one of the ends of T L 1 as the center, and the radius as T L 1 join arc, and taking T L 2 as dimensions with this vertex is centered; draw infect cut the previous arc with the new arc. And keep cutting these arcs, how many times I going to be cutting?

Student: 8 or 9.

8 or 9 keep cutting, and all these lengths they are going to be what? T L 2 ok. So, they has to be they have to be how many cuts? So, 1 2 3 4 5 6 7 8 corresponding to the number of vertices that you see in the top view there yeah, and of course join these points with the center. So, what you have is something very simple. So, if you make this sector out of a paper, and fold it at these so speak lines, you will get the solid back, right.

(Refer Slide Time: 17:20)



Pretty simple, this make our life alive is a little more complicated. What if the pyramid is truncated, what if I have a plane that is cutting the pyramid. Then, what the base will be the same, so will have to be working with this entire picture over here, just that we have to be a little worried about the intersection points between the optical pyramid and this plane, yeah. So, let us try to figure the intersection points first. You need to know where the intersection points are; where are they going to be lying? Where are the intersection points going to be lying? Well I mean; we have these edges right, so the intersection points that have to be lying on a plane. This plane and they also have to be lying on these corresponding edges, all you need to do is like project those intersection points on top view, and the right side view, alright. So, keep projecting.

So, this one lies on edge number 6, this one lies on edge number 5, 5 and 7 kind of 5 perhaps. So, keep projecting and you essentially will be figuring out these intersection points, and the top view. All except for 2 of you those intersection points which will be lying on the vertical edge over here, number 4 and the edge behind it number 8. So, 4 well 4 is behind, so number 8 which is facing you, and number 4 which is behind yes. How do you figure those points on section?

Student: ((Refer Time: 19:15)).

You can make this projection perhaps. So, if you can make this projection this is number 8, this is number 4, you will be getting the corresponding intersection point over here, and over here. Project them backwards, and on to the top view and get those intersection points. Or, otherwise; if you want to be a little more tedious, may be make any measurement, make the hinge line make be the same measurement over there, make the hinge line. You know, and something that you have learnt in your lines and planes thing. So, measure that distance transfer that distance over here, and measure this distance transfer these distances over there. So, these are your two intersection points, and the second of course; was quite right.

So, you can directly project those intersection points from the profile view, and transfer them on to the front view. So, these are your intersection points; I am not labeling them. So, labeling is something that you will have to do later. And join those intersection points to get this contour, ok. Now, when I say that the pyramid is truncated, I essentially men that this part of this pyramid is taken off, and it is replaced by a plane covering the top version of the pyramid. So, this would be top led of this pyramid, what is the bottom length? The octagonal face 1 2 3 4 5 6 7 and 8 the octagonal face, alright. Ok, so you can as well project these intersection points onto the profile view, get them on the respective edges of the octagonal pyramid and complete the contour, right. Is this contour in true shape, is this contour in true shape, what did I say; so if you have to transfer everything in such a way that you have to lay down those features on a plane; you have to get the corresponding things in the true shape.

Well, so this is the actual truncated pyramid that you see; the actual truncated pyramid that you would see. The top version of the pyramid is gone, this is the top led off the pyramid which is covered, so the pyramid is not open, and of course; the bottom face of the pyramid is covered by that octagonal face. Alright, always label the points so; I made a mistake of not labeling the points. But you should be always labeling these intersection points, every point that you are working with in your intersection and development exercise, always label them.

Now, I am labeling those points a b c d e correspondingly; a over here, the true b's, a b c d e would go you know from here to here, a b c d e would come from here to here alright. So, always label your intersection points, alright. So, I am done pretty much, now I need to get this contour in true shape. Yeah;, so something that I will delude you. It always has to be the true lengths and true shapes that need to be transferred onto the piece of paper, and we need to find them as a part of the exercise and development. Alright, now let us worry about this little later; let us worry about this little later. Let us worry about the rest of the edges. Look at this edge; this edge would lie on which edge of the octagonal pyramid 6 or 2, 6 or 2. What is the corresponding projection? What is the corresponding projection in the front view? This one? So this is edge number 2. Is this in true length? Yes sir. So, this is in true length it should be possible for you to transfer that length over here. Well, is there any clue that you are seeing here? No, that is fine.

How about this entire thing? This is on which edge? Number 6. The corresponding projection, the corresponding projection here is this in true length? Yes sir. You need to transfer that onto edge number 6 there. So, the intersection point over here would be a and the intersection point over here would be e always label. Yeah, alright. Let us look at this edge; intersection point c alright. So, where is it? Can you identify the corresponding projection in the profile view? c would be on 8 and it could also be on 4. So, 4 and 8; 4 and 8 yeah. Is this in true length? Yes sir. Alright, so it should be on 8. Is this also in true length? Yes sir. Great, so it should be on 4 wonderful.

How about the lengths on edges number 1 7 5 and 3; lengths on edges number 1 7 5 and 3? So, 5 7 are here 1 3 are here. So, if you are looking at the corresponding edge over here and its projection there. So, this is slant and so it is this. So, is it possible for you to extract the true dimensions directly from these 2 got from the information given? It is possible no algebra no fractions just geometry. No root 2, root 3, root 4, root 5, no pie just geometry. I will come; I will come there alright. So, these are intersection point c alright. What about the rest? We are trying to address that. Ok, so look at this projection and try to figure the corresponding projection in the top view. b 7; b 7 is this one, b 5 is this one. Yeah, I will I will do a little trick. So, what I will do is; I will displace the line in both views.

I will displace the line in both views. I will displace the line in such a way that one of the vertices of this line; the true line lies on vertex number 6. You follow that you follow that? Just rigid body displacement; I have kept the lengths of these corresponding projections are the same just rigid body displacement. And just in case if you remember the method of rotation to figure out the true length. Precisely, if you do that if you rotate this; if you rotate this then what will happen to this projection? You take a projection from this point here down, this height would remain the same and eventually this guy would come here, Just using the method of rotation, yeah. So, what you have done? So let me go back. So, you have identified these projections, made rigid body displacement, you know shifted the line such that what are the vertices of the line lies on number 6 edge number 6. Follow the method of rotation, when you do that this guy gets rotated to lie on slant surface yeah.

Now you have the true length. You have the true length for what? This guy here b 7 and b 5 as well; yeah gave that true length and perhaps transfer them. Likewise I can do the same thing for this. Identify this projection in the corresponding projection is 1 d and on top its 3 d not 3 dimensions but 3 d. Shift, follow the method of rotation. This guy gets rotated to lie on this slant edge; yeah. There is just fault, no there is just for you to understand. One method that I am going to be talking about now is going to be much simpler.

So, what you realize is whatever length you have here; whatever lengths you have here, if you just project them in such a way that they all happen to be on the slant edge of this pyramid. Essentially you are going to be getting the true lengths over here. This is where I am coming to realize that to get the true lengths you need to project the intersection points onto the extreme right or left edge of the solid. Yeah;, so this point is lying on this edge; this point projected over here; from here to here you will get the true length. This point again projected onto the extreme left get the true length. Likewise for d and point e is already there right. So, if you project all these intersection points so that they lie either on this edge or this edge the corresponding lengths they will all be in true length, which is a much simpler method.

So, these are the corresponding projections either on the left or in the right. So, once you have these projections, transfer them onto that piece of paper. Draw the radii or draw the arcs if you want to; you do not have to, but if you want to draw complete arcs. But what is of interest to ask are these edges; edge number 1, number 7, number 5 and number 3 this is where we want the true lengths to be yeah.

Alright, so let us work with edge number 1. This length is what? This length is this point getting projected over here so it is this length. It is on edge number 1, so 1 here and the other 1 here and so is the case with edge number 3 also yeah. So, this is 1 and this is 3. So, 3 of these lengths they get transferred. How about number 5, number 7? p projected over here; so it is this point here alright. So, first label and this is the true length on edge number 5 and this is true length on edge number 7 same. Are you with me? Yes sir. All of you? Yes sir, by the way, my tea cup. How many of you think that this is actually a torus; a torus? This is actually a torus. Is that true or not? Have you ever played ring? That ring is a torus. Do you remember playing ring when you are kids or even now? That is a torus. So, this cup is actually that ring. Do you believe me; do you believe me? You do not believe me? Louder; do you believe me? No sir. Alright, but that is true this is actually a torus.

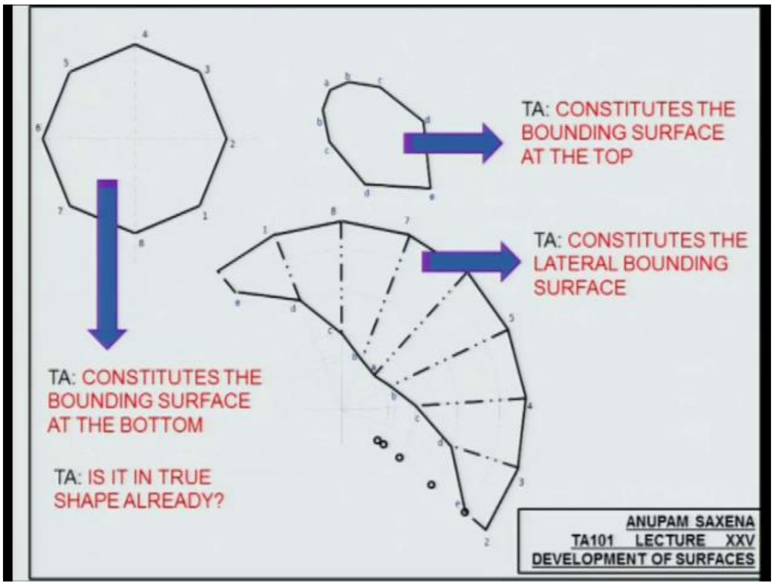
Anyhow, you know there is there is something called topology; science of connectivity or discipline of connectivity. So, you learn things about connectivity story about connectivity in there. So, many of the guys in electrical computer science they will be learning about networking network that is connectivity innovate. So, you know in your third year, in your fourth year when you learn about topology; when you learn about homeomorphism that is where you will actually figure that this is a torus. But that is too late for you.

Now, this time at this time its engineering drawing. So, alright so once you have transfer; once you have transferred all those true lengths on the respective edges and labeled the intersection points properly alright. So, I will make a little change. So, what I will do is that, I will change the color; I will change the color of these lines and also will I change the representation of these lines, instead of denoting these lines as solid lines and denoting then using hinge lines. Why? Because, that is so those are the locations where I am creating foals; those are the locations where I am creating foals to get the solid back right. To represent that the paper is pinned or folded at these edges and then of course, close contours. So, if you take a piece of paper cut it in this fashion, fold it at the respective locations that are denoted over there you will get that solid back. With the difference, with the difference the bottom plane at the top lid they will not be there. So, it is going to be an open truncated pyramid, let us work on that.

Again, so you are going to be working with graphite pencils. So, your drawings going to be great, not colorful. To get the top lid, once again if I may remind you that you have to get true features and transfer them onto the paper plane right. So, you need to determine the true shape of plane a b c d e d c b a, so this plane right here. You know how to get the true shape of a plane? Do you see the edge view of this plane; do you see the edge view of this plane? Yes sir. Which view is it in; which view is it in? Front view. Alright, draw hinge line true projectors perpendicular to that hinge line. Transfer distances; transfer distances, you know that so I am not going to be going through it once again. Transfer distances and then get the true shape of that top lid alright.

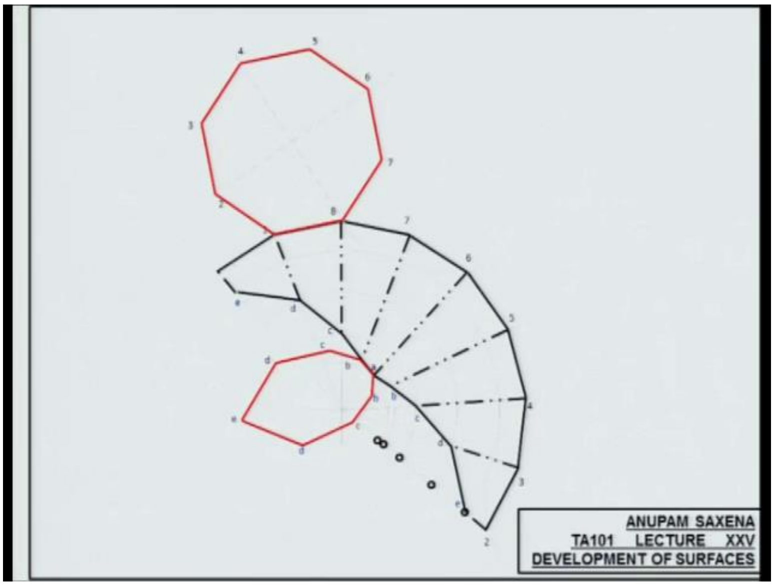
So, where is this lid going to be? Of course, we have to label these points also. So, where is this lid going to be? Somewhere over here or somewhere over there. Where is this lid going to be? Well, it is going to be somewhere over here. Yeah, let us worry about that in a while. Alright, so by convention this is what we do. We start developing, we start the developing the surface in such a way that we start with the shortest edge on the surface. So, if you look at these edges, if you look at these edges and if you figure out the lengths of these edges; you will find that this would be the shortest in length and you start with that. So, the edge you start with you have to end with the same edge, because you have to glue the corresponding edges. So, this is what I have done. So, instead of starting with the edge number 1, I figure that edge number 2 was the smallest; 2 e was the smallest, so I started and ended with edge number 2 e ok. Conventionally start development with the smallest edge and end with the same.

(Refer Slide Time: 40:19)



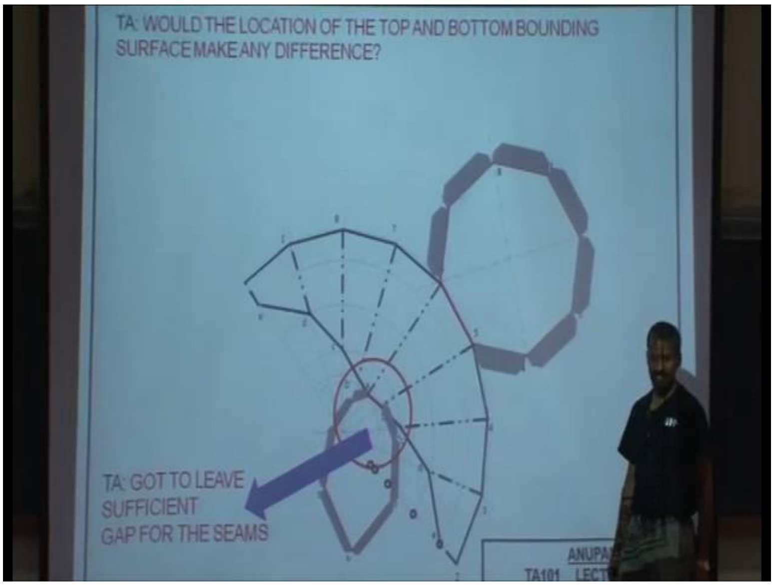
So rest of the information is taken away. What is important is the lateral surface of the solid the top lid of the solid and the bottom face of the solid. This one constitutes the lateral bounding surface of the solid, constitutes the top bounding surface of the top lid the bottom face that is of course, in true shape.

(Refer Slide Time: 40:57)



What you need to do is, rotate these guys and align them appropriately onto the main developed thing. So, notice where I am aligning this face over here. So, notice a b and looks like I am aligning the 2 a b’s together, right. Likewise, rotate this top face and align the corresponding edges appropriately. So, I align one edge together so align this guy with this guy right. Now, that is a single cut that you need to make to get the entire solid back. Yeah, a single cut you need to make on a single piece of paper to get the entire solid back. This is what development is. If you cut this paper fold it and glue appropriately, you will get the bounded truncated pyramid back. Is the location of these 2 planes important, are the locations of these 2 lids important, these 2 faces important. Can you locate them anywhere? Theoretically can you locate them anywhere?

(Refer Slide Time: 42:40)



Would the location of the top and bottom bounding surface make any difference? So, for example, if I choose to locate the bottom face there and the top face here. Should be ok should be ok. Yeah, do not forget to introduce the c, those are little extra things that you would want to provide over here. So, that when you fold the solid back or when you fold the solid you should be able to provide enough paper to be able to glue the solid back. So, like so these are the seams right. So, if you fold the seam over here if you fold seam back you know, so you are going to be gluing at these little pieces of paper over here and over here. Now figure what the problem is, figure what the problem is? So, if you allow for a little extension at this location, this is interfering with this lateral develop laterally develop surface, Yeah; this location here.

So, you got to leave sufficient gap or space for the seams. So, something that you will probably want to keep in mind. Here, you want to say that this is to be represented by well technically alright. So, if I may repeat what is your name? Shubham. So, what shubham is asking is, whether this line is to be represented using the hinge line convention, Will be same logic that well you are also folding you are also making a fold here. Alright, any other question? Were you with me throughout, were you with me throughout? Yes sir. Were you with me throughout? Out of the blue, yeah. Alright, can I have my solids back; can I have my solids back please? Yeah, should not there be a 2 e here? Yes sir. There should be true truncated top view yeah. So, do you agree? Wait, do you agree that the important thing for ask is to show the true shape of the open lid of the top lid? It does not really matter how you get it so long as you get it, any other questions?