Physical Modelling for Electronics Enclosure Using Rapid Prototyping
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Lecture - 22
Demo of 3D Part Print

Hello if you remember yesterday we stopped with this saying I have a small circuit here.

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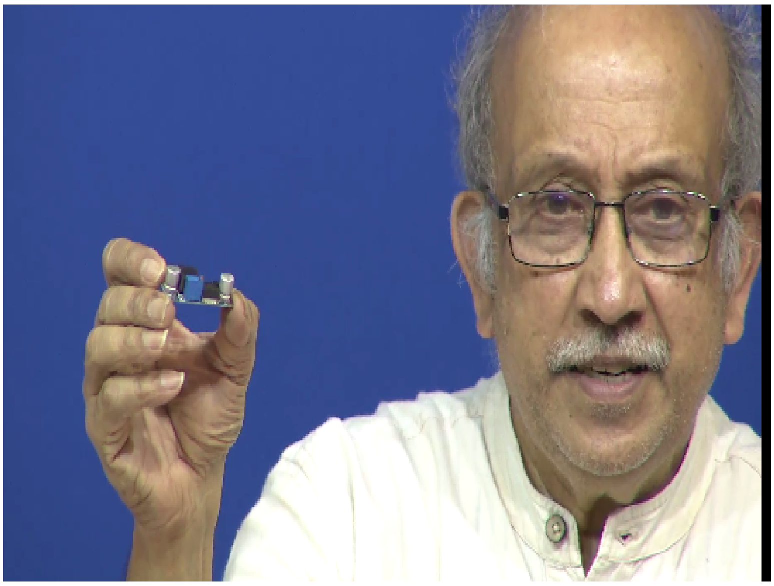

Can you zoom it in sir? I would like our students to see this as much as you can. I think that is probably the maximum it is fine. If you remember we started here.

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Then I also tried to show you a small enclosure which I can build with it. I was feeling very thrilled about it. Now finally that job has been find. I have the video there which I will show you in due course and then this is not asymmetrical objects. So a lot of care has been taken and once I put it just directly it comes out of the machine sits flush how nicely it sits. I am thrilled at it okay I will put it this side maybe it is convenient for me.

Can you see here it is absolutely flush and more than anything else I have a provision for a heat sink there. So this aluminum what you call part. Right now no I have not yet finish it. I have got something which fits perfectly all right all I need to do is attach 2 more screws here and for which also I am trying to make some arrangement and make sure that there is no short circuiting here compare this to what we did some years back.

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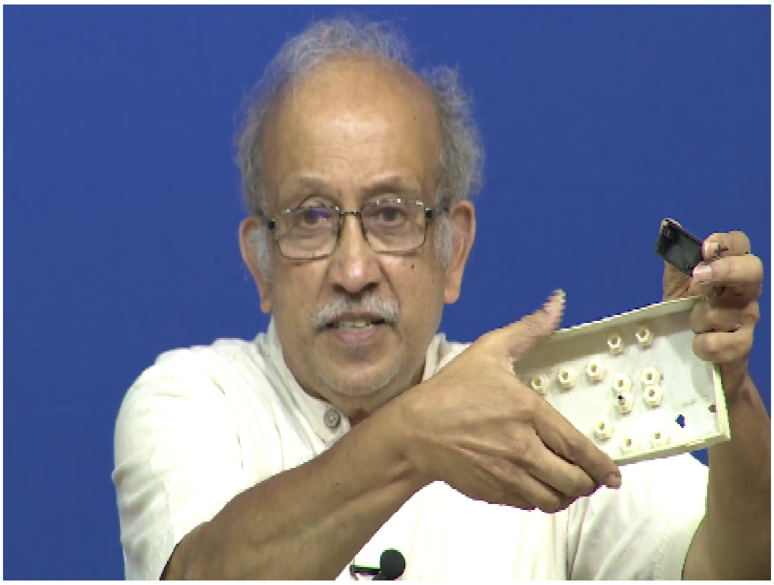

This is done 6 years back in a little older machine you see this here, but of course the whole thing is there we are not very sure. And then this whole thing has a chance for it to buckle. So we had to strengthen it using extra sheets and all the sides because the build up and all and the size was a problem.

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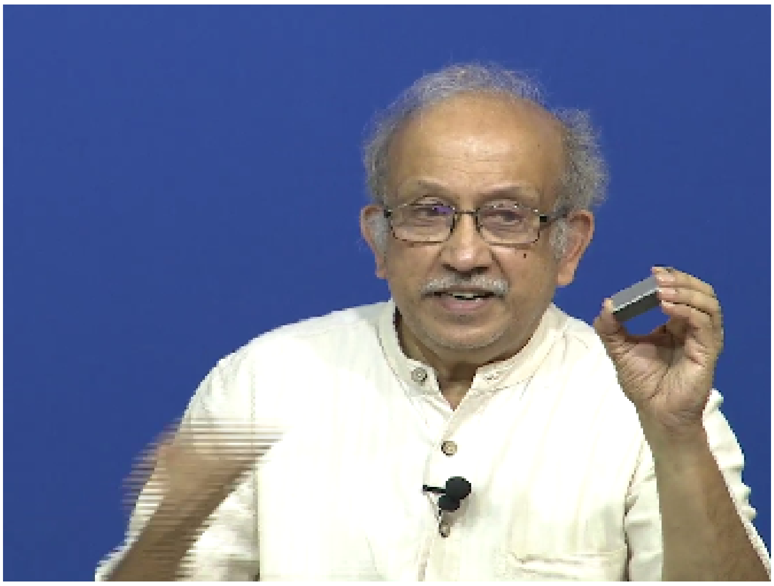

Right now making things like this is easy extremely easy there is no issue about it at all and if you make a proper drawing with all the trouble we have taken and then the first firing of the job everything sits neatly inside. This is the advantage of so called 3D printing. Now one of my friends have asked me a question sir what next. This is as an experimental thing I wanted to show you one more time let me tell you this is very miniature thing.

And it is going to use 2.3 mm self-tapping screws. It is a little smaller than the standard ISO we have 2.6, 2.5 (()) (02:50) we have 1.6 and 1.5 compared to that eventually this is going to sit here. This is a very farfetched idea from where we have started. See here we did not know all that story I was telling you how to make it and all that it has been taken care of. Now the technology has also improved.

And we did not even need this hard what you call metal inserts unless we wanted. In fact, if you see this next model is probably going to have a small projection here. If I have the projection, I just have to push it inside and it just stays there without anything and I do the same projections can come out and then I can even assemble the heat sink and where it comes out I make some arrangement I have a beautiful model which works.

And more than anything else I do not know if I have shown you or anything there are small grooves here which will make sure that a wire can sit through it. So I have a beautifully made module from off the shelf electronic. Every time we did not invent the electronics, but you need to invent products so I will see how it was yesterday.

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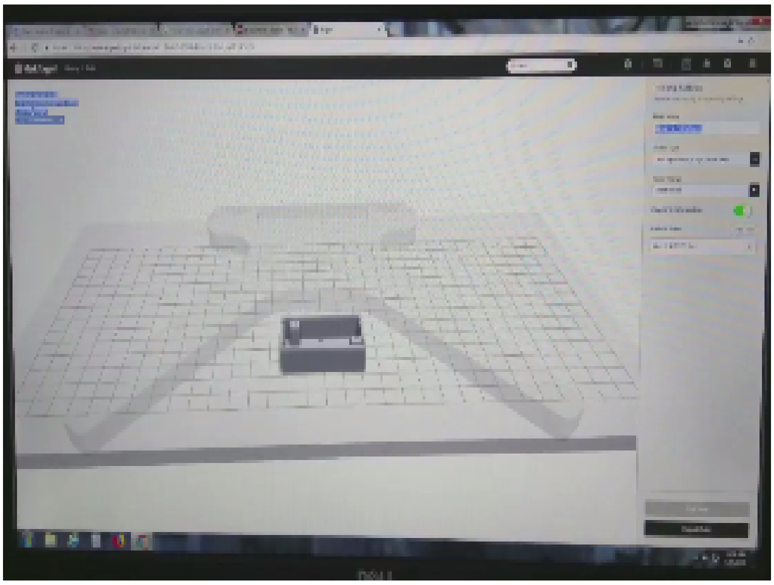

This is what I had shown you.

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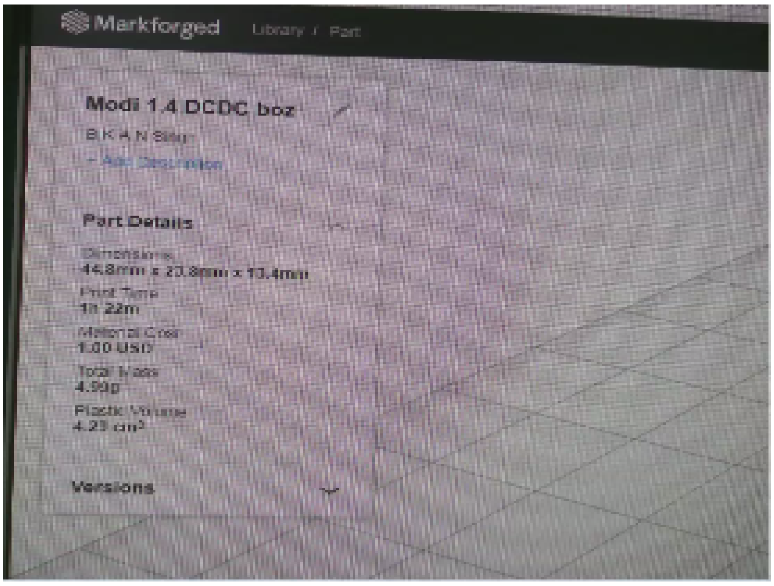

Then this is detailing which I had shown you.

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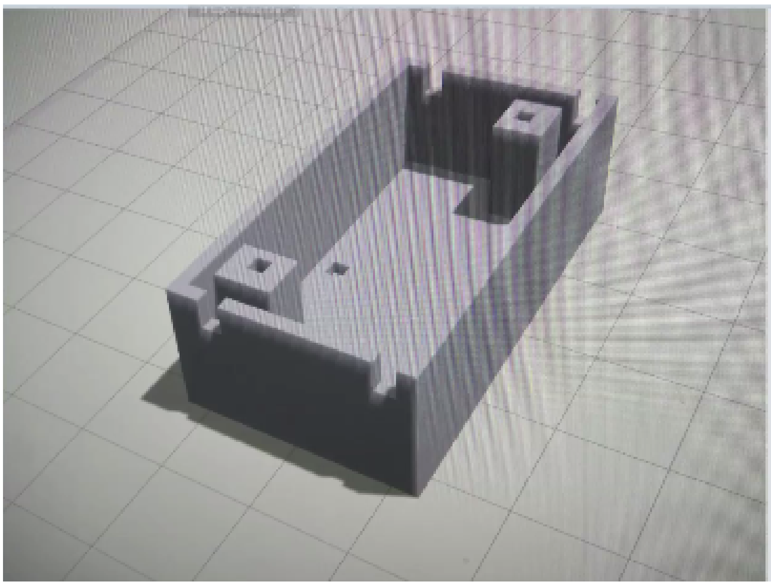

This is the box and this is how the whole thing was built up. Now I will see if video which I took will actually show up. Bigger video has been taken with a big camera, but right now this is small what do I call it a trial video to show how the parts are being build up. So just wait I hope it loads. Yeah it is coming there.

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That is Mr. Singh my colleague who does actually all the printing and all that I do the talking and he does the working. Let me stop it here rather pause it here and try to explain a few things here. First of all, this device has several stepper motors. For visible one on the top is the steeper motor here with a belt and which has a drive which moves it in the x direction. If I take it left to right as an X direction.

And then I have one more steeper motor here which by a very clever arrangement of a belt which moves here will move this from the left and right. Advantage being we have avoided loading this high speed moving device. The minimum weight is there and then let me play it. So you can just because the amount of what you call gap which is given there is very, very small we cannot see things that easily.

The video we have from this camera and one more camera you can see it subsequently when we upload it. Can you see here this is as (()) (07:17) which will feed one of the materials. In this particular machine we can have a material which can have 2 types meaning outside can be the basic material and inside we can have a core of any these things including cavalier and including carbon fiber and so many of those things will sit inside.

We are almost coming to the end. Can you see at this point? let me pause it again. There is what you call basic (()) (08:05) and this is that vertical table which I showed you in the drawing with a peculiar what you call gamma shape. So you a feed screw here underneath next set of step motors and controllers and all are there. So this moves up and down this will give you a Z axis the other two will give you the other axis.

And in this machine they have made it a little simple by making a display directly here. So it is easy for us probably after I. We have almost come to the end of it there is not much more to go. It is just a repeat I will leave it here. Now here is where we come into the other interesting things.

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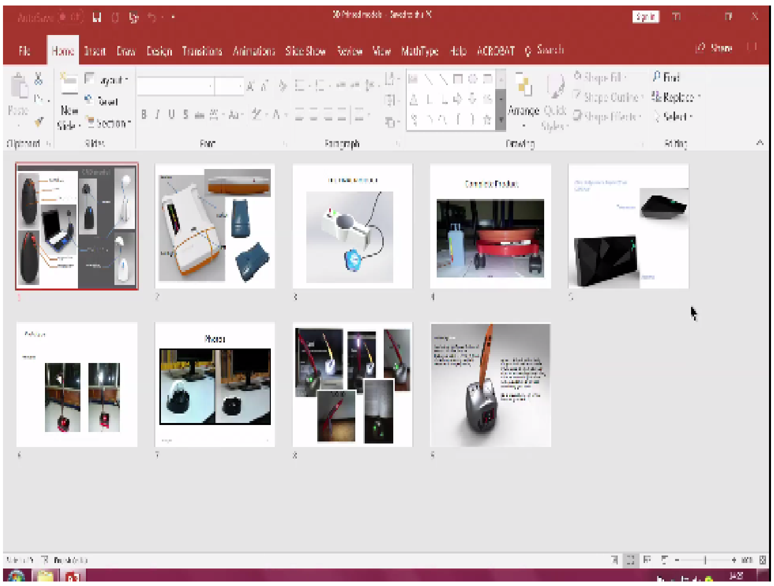

Now if you can kindly look at my monitor here. So you see here over the years my graduate students have been working on such projects and I will repeat it later so did not worry too much about how you would like to see it or anything see here.

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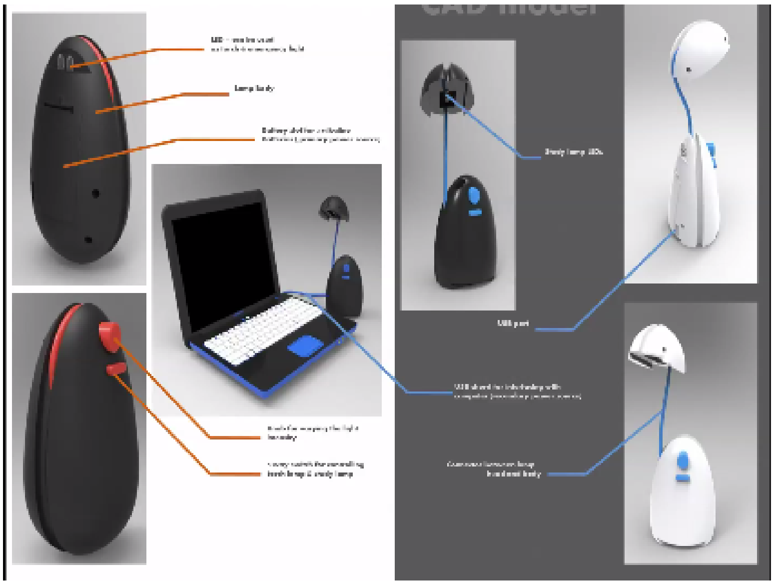

So there is something about some lamp and that lamp does all these functions and all.

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If you remember similar lamp I had showed you here. This is a very, very interesting thing. This is the CAD model on the left side this is typically the rapid prototyping what we have achieved. This is what I keep telling you there the beautiful surfaces you see here do not automatically come there in contrast to what I have shown you already. I am going to talk a little more about it because I am one of those coffee addicts of and on show me this sir.

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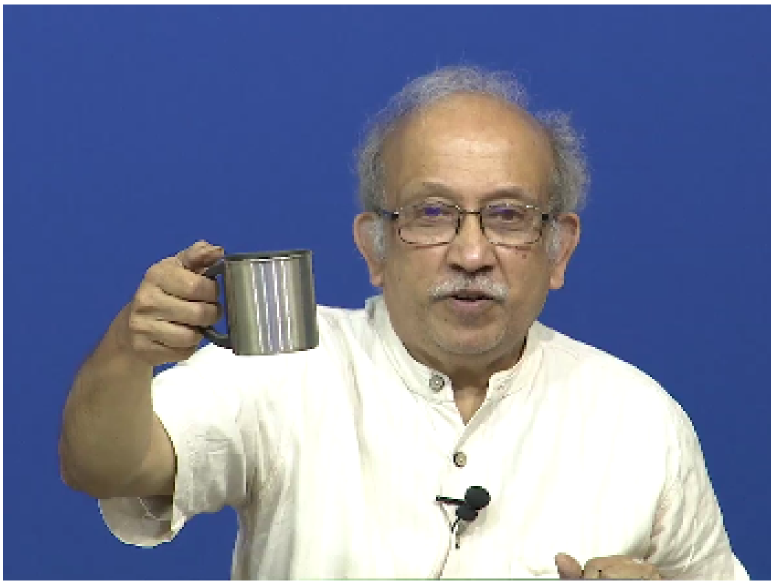

Can you please show me this tea cup? I would like to have warm tea. So one student worked on it and find out whether you know how to satisfy my craving for caffeine. We have something and we have this I am sure lot of you have seen this. Now next part of the lecture is going to be this. It is somewhat related to the product that you see here at the bottom. So kindly show me this sir you have seen this.

Now you see carefully in this several things have gone into until it came here something else we have gas thing and we have something else again here. You see this all the beautiful stuff here and so on and this is sort of what do you say I call it the ultimate thing for what the students could manage. So I will stop here I will get back to one sample how to make things. So please keep looking at it.

See if you have to go to the internet and check what are all the guidelines for 3D printing I will see if these things open surprise we do have what you call external access is there. I will just type in and see how good we are.

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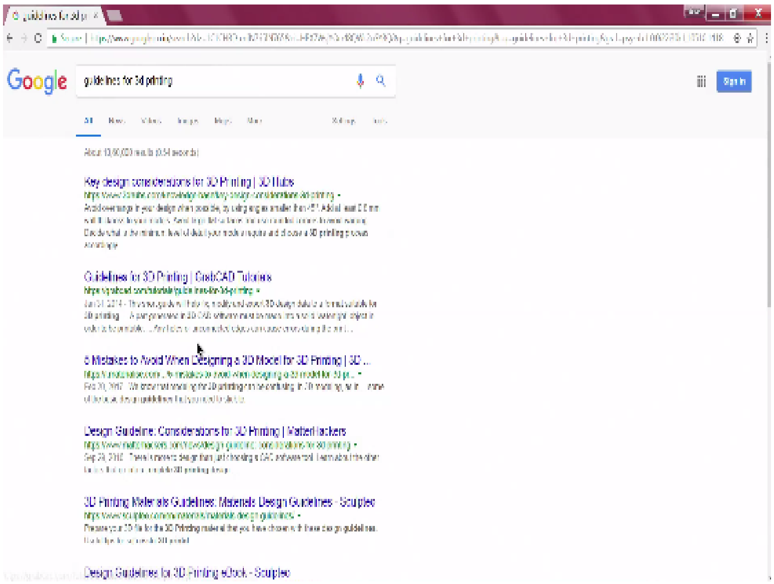

So if you just go and say guidelines for 3D printing. We have various things here saying guidelines for 3D printing and type of materials and so on and so on. I would like to come to one of these things which we have tried to use earlier. This is made by the manufacturer. The first status is machine we have had. You will notice that this is very authentic and even today they are one of the leaders in (()) (12:28).

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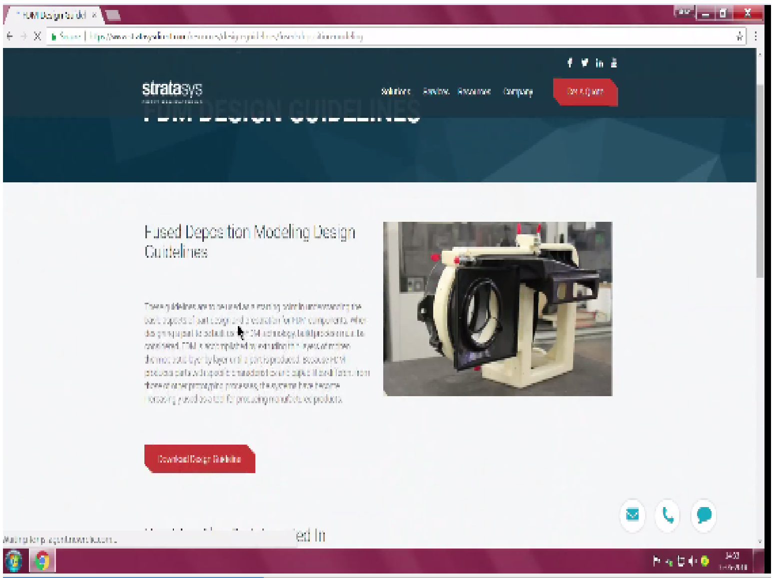

So if you go down there is a download design guideline is there. It is almost there see. This is what we have been using all along. Stratasys we have been one of the people which we were familiar to work with. So I am not very sure whether it is heater assembly or anything. Then we have this stuff about part design considerations. Fused deposition modeling design guidelines, part design.

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The issue being here is to be used as a starting point and understanding the aspects of part design and preparation for components. When designing a part we built using build process must be considered. FDM is accomplished by excluding thin layers of molten thermoplastic layers by layer until a part is produced. Because FDM produces parts with specific characteristics and so on. So we have blah, blah and all that.

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And one of the blah, blah finally we have here saying FDM system add small amount of molten materials in a heated environment, warp is not a common problem. However, to avoid potential warping of a vertical walls when building thin walled sections designers must select to add ribs and so on. So next page gives you lot of stuff about holes.

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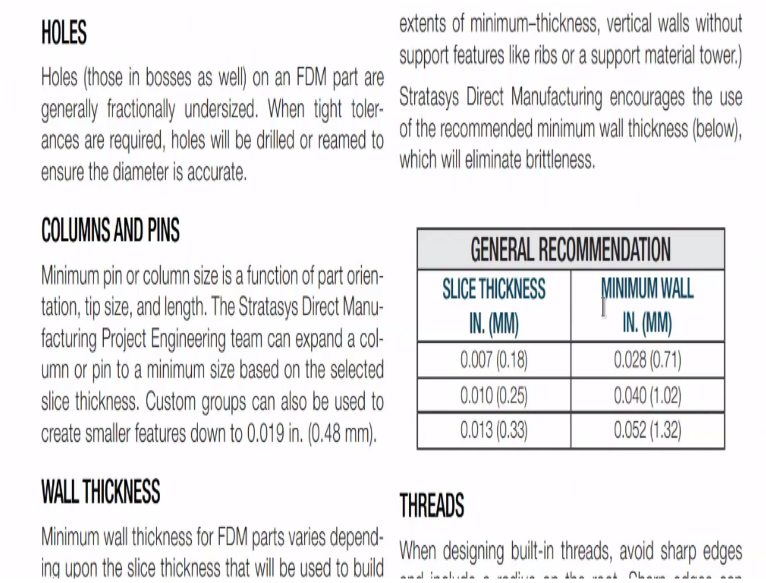

HOLES

Holes (those in bosses as well) on an FDM part are generally fractionally undersized. When tight tolerances are required, holes will be drilled or reamed to ensure the diameter is accurate.

COLUMNS AND PINS

Minimum pin or column size is a function of part orientation, tip size, and length. The Stratasys Direct Manufacturing Project Engineering team can expand a column or pin to a minimum size based on the selected slice thickness. Custom groups can also be used to create smaller features down to 0.019 in. (0.48 mm).

WALL THICKNESS

Minimum wall thickness for FDM parts varies depending upon the slice thickness that will be used to build

extents of minimum–thickness, vertical walls without support features like ribs or a support material tower.)

Stratasys Direct Manufacturing encourages the use of the recommended minimum wall thickness (below), which will eliminate brittleness.

GENERAL RECOMMENDATION	
SLICE THICKNESS IN. (MM)	MINIMUM WALL IN. (MM)
0.007 (0.18)	0.028 (0.71)
0.010 (0.25)	0.040 (1.02)
0.013 (0.33)	0.052 (1.32)

THREADS

When designing built-in threads, avoid sharp edges

An FDM parts are generally fractionally undersize. When tight tolerance are required, holes will be drilled or reamed to ensure the diameter is accurate. You have seen this here most important thing here is up to a point you get accurate features beyond that we need to make things by finishing them. The second operation is a must or in case any other way is over. Then we have stuff about this slice thickness and wall thickness and you have seen this about threads.

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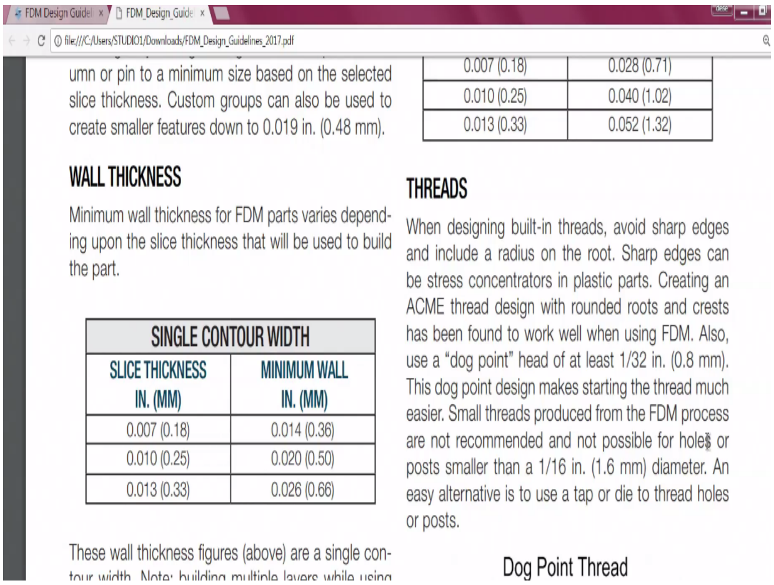

umn or pin to a minimum size based on the selected slice thickness. Custom groups can also be used to create smaller features down to 0.019 in. (0.48 mm).

0.007 (0.18)	0.028 (0.71)
0.010 (0.25)	0.040 (1.02)
0.013 (0.33)	0.052 (1.32)

WALL THICKNESS

Minimum wall thickness for FDM parts varies depending upon the slice thickness that will be used to build the part.

SINGLE CONTOUR WIDTH	
SLICE THICKNESS IN. (MM)	MINIMUM WALL IN. (MM)
0.007 (0.18)	0.014 (0.36)
0.010 (0.25)	0.020 (0.50)
0.013 (0.33)	0.026 (0.66)

These wall thickness figures (above) are a single contour width.

THREADS

When designing built-in threads, avoid sharp edges and include a radius on the root. Sharp edges can be stress concentrators in plastic parts. Creating an ACME thread design with rounded roots and crests has been found to work well when using FDM. Also, use a "dog point" head of at least 1/32 in. (0.8 mm). This dog point design makes starting the thread much easier. Small threads produced from the FDM process are not recommended and not possible for holes or posts smaller than a 1/16 in. (1.6 mm) diameter. An easy alternative is to use a tap or die to thread holes or posts.

Dog Point Thread

And you see the last thing here. An easier alternative is to use tap or die to thread holes or posts. So in case you have a thread thing carefully if you can match the what you call the (()) (15:08) diameter the manufacturer himself says kindly tap the holes. There is a must for it.

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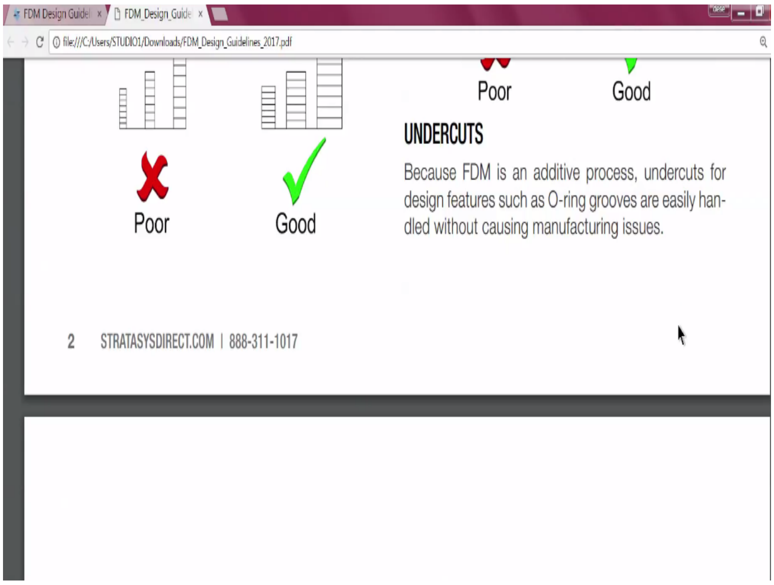

Further if you go down. FDM is an additive process undercuts or design features or o-ring grooves are easily handled without causing manufacturing issues. I agree and I do not agree also. So in this part he has given stuff about how to reduce stress concentration, how to make it and all that and I kept on telling you about it saying draft is unnecessary an FDM part. And single FDM parts has large you can leave all that.

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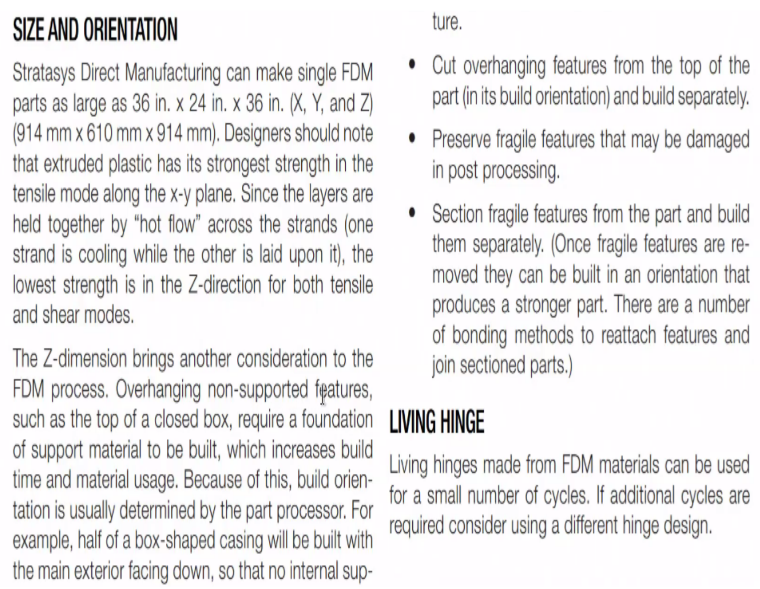

Overhanging non supported features such as top of closed box require foundation of support material to be built which includes build time and material usage. So how you orient the product on the table is very, very critical.

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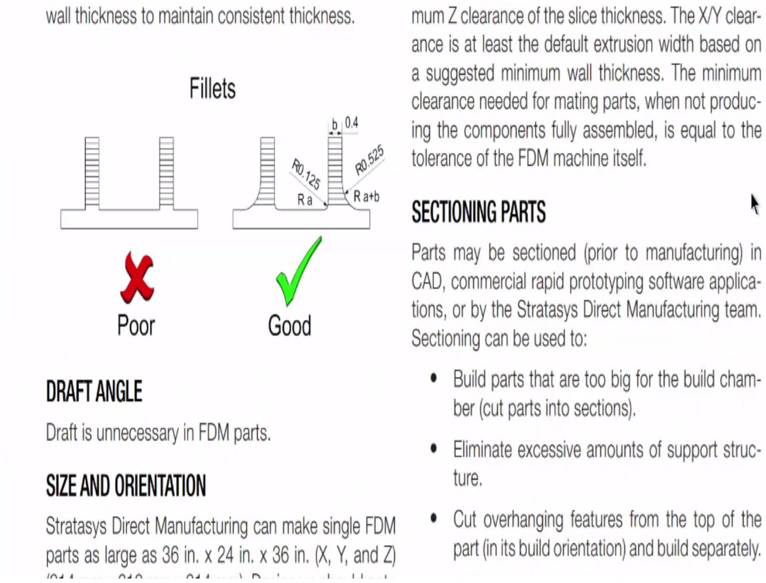

wall thickness to maintain consistent thickness.

DRAFT ANGLE

Draft is unnecessary in FDM parts.

SIZE AND ORIENTATION

Stratasys Direct Manufacturing can make single FDM parts as large as 36 in. x 24 in. x 36 in. (X, Y, and Z)

mum Z clearance of the slice thickness. The X/Y clearance is at least the default extrusion width based on a suggested minimum wall thickness. The minimum clearance needed for mating parts, when not producing the components fully assembled, is equal to the tolerance of the FDM machine itself.

SECTIONING PARTS

Parts may be sectioned (prior to manufacturing) in CAD, commercial rapid prototyping software applications, or by the Stratasys Direct Manufacturing team. Sectioning can be used to:

- Build parts that are too big for the build chamber (cut parts into sections).
- Eliminate excessive amounts of support structure.
- Cut overhanging features from the top of the part (in its build orientation) and build separately.

So a little bit of data or what you call thing is there saying parts may be sectioned prior to manufacturing in CAD, commercial rapid prototyping software or by this direct manufacturing so on. Parts that are too big for the build chamber into smaller parts. Eliminate excessive amount of support structures. Cut overhanging features on the top of the part. Preserve of fragile feature that maybe damaged in processing.

Section fragile features from the part and build them separately. Then we have living hinge for a critical thing I have explained to you there for a prototype process. For a small number of cycles, you can bend the materials. In additions cycles are required consider using differing hinge design.

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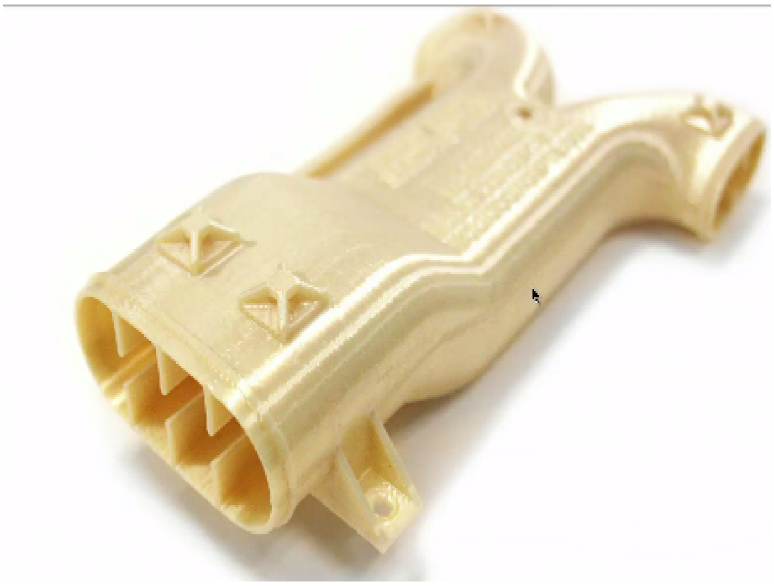

So we have here a nice what you call you have seen this I do not know what it is, but you will see here something very, very interesting to do is you see this mounting holes and also you see something here on top probably that takes a strap. I do not know if it is a connector or whether a wire is coming here or what it is. You see that lot of detailing it is slightly different from equivalent injection moulded part.

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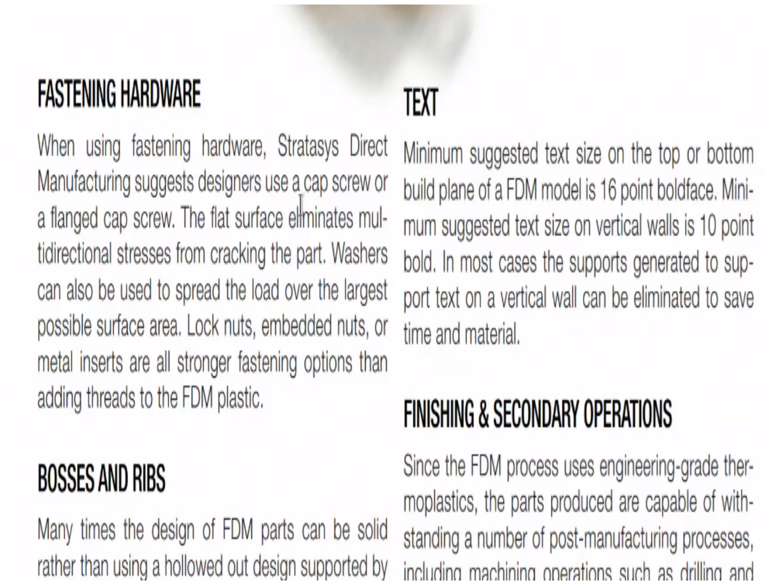

When using a fastening hardware use a cap screw or a flanged cap screw. The flat surface eliminates multidirectional stresses from cracking the parts. Washers can also be used to spread the load. So this is a must. So you make your thing as best you can do and they have given here saying you know in the final job around 16 point something which you can build.

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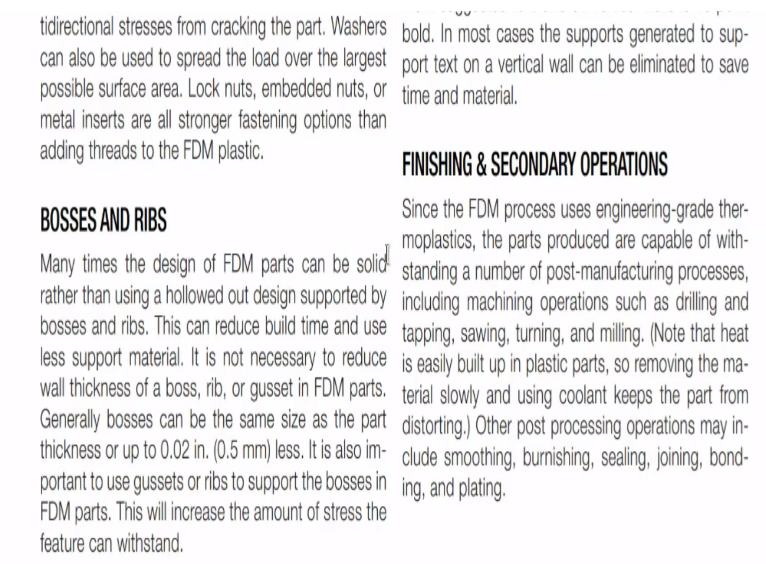

Many times the design of an FDM parts can be solid rather than using your hollowed out design supported by bosses and ribs. This can reduce build time and useless support material.

It is not necessary to reduce wall thickness of a boss, rib or gusset in FDM parts why they have done it because unlike in the injection moulded process here there is nothing wrong in having varying cross-sections.

And you see the second point. FDM process uses engineering grade thermoplastic. The parts produced are capable of withstanding a number of post-manufacturing process including machining, drilling and tapping, sawing, turning and milling. Heat is easily built up in plastic so remove the material slowly and use usual stuff (()) (19:19). Now I will quit this particular thing and go back to other considerations. I will say this is what I have shown you.

Now other people also know for example design consideration, stuff they are equally valid why I am showing you this is I have experience only one machine one type of jobs, but here obviously there are people who have been working on it and this is probably a book like thing is available. This is a picture I showed you earlier.

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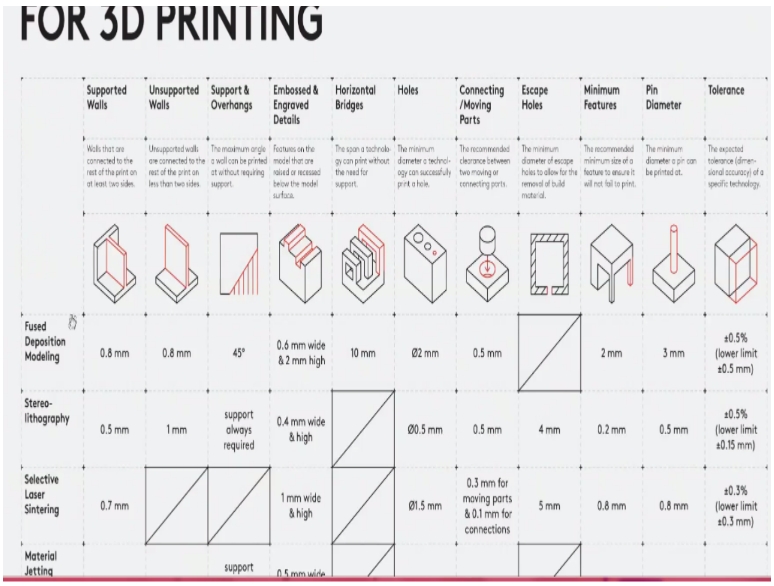
FOR 3D PRINTING

	Supported Walls	Unsupported Walls	Support & Overhangs	Embossed & Engraved Details	Horizontal Bridges	Holes	Connecting /Moving Parts	Escape Holes	Minimum Features	Pin Diameter	Tolerance
	Walls that are connected to the rest of the print on at least two sides.	Unsupported walls are connected to the rest of the print on less than two sides.	The maximum angle a wall can be printed at without requiring support.	Features on the model that are raised or recessed below the model surface.	The span a technology can print without the need for support.	The minimum diameter a technology can successfully print a hole.	The recommended clearance between two moving or connecting parts.	The minimum diameter of escape holes to allow for the removal of build material.	The recommended minimum size of a feature to ensure it will not fail to print.	The minimum diameter a pin can be printed at.	The expected tolerance (dimensional accuracy) of a specific technology.
Fused Deposition Modeling	0.8 mm	0.8 mm	45°	0.6 mm wide & 2 mm high	10 mm	Ø2 mm	0.5 mm		2 mm	3 mm	±0.5% (lower limit ±0.5 mm)
Stereo-lithography	0.5 mm	1 mm	support always required	0.4 mm wide & high		Ø0.5 mm	0.5 mm	4 mm	0.2 mm	0.5 mm	±0.5% (lower limit ±0.15 mm)
Selective Laser Sintering	0.7 mm			1 mm wide & high		Ø1.5 mm	0.3 mm for moving parts & 0.1 mm for connections	5 mm	0.8 mm	0.8 mm	±0.3% (lower limit ±0.3 mm)
Material Jetting			support	0.5 mm wide							

See we have a lot of guidelines given here saying what to do with supported walls. So we have stereo lithography, selective laser sintering and fused deposition and fused modeling and all that lot of stuff about what is the minimum thickness that you can have has been given here supported overhang. Can you see here I will try to enlarge it as much I can. See here the movement.

There is an angled wall it ends up with this red colored thing is the support which is build automatically into the machine. This machine will give you these building things about it.

Then you have embassed and engraving details that is how deep something can be or it is there so they have given 0.5 mm then there are bridges saying. If you have a hallow span a technology can print without the need for support how much as you keep building you can build something across and you see here.

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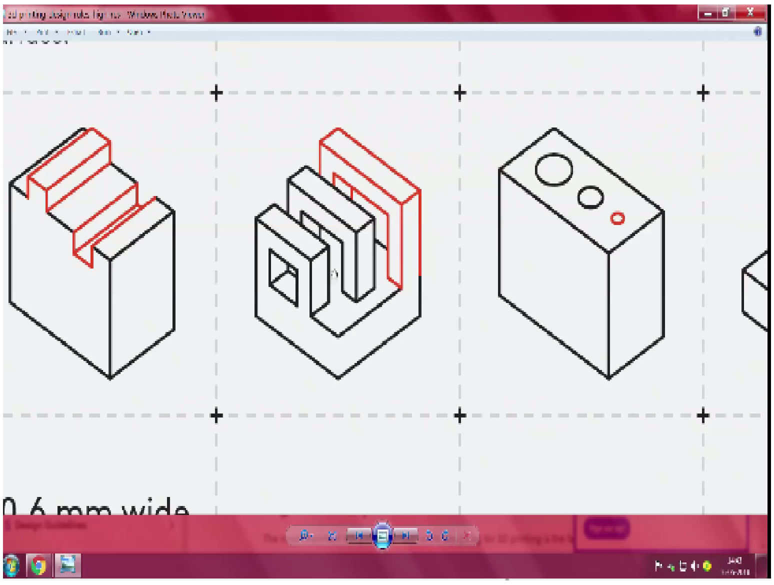

If you see these things here. You see this hole in between there is no support similarly here no support here, no support here happily it is able to build then minimum diameter can successfully print all almost at a time it is about around 2 mm. Secondly recommended clearance between two moving or connecting parts saying if you give around 0.5 mm it will be able to build this thing. Escape holes to allow for the removal of build material.

So they have given stuff this size of the feature then the pin diameter features how well typically around 3 millimeter is the pin which can stand by itself. There is also related to height also about it. So it is not correct for us to make thin tall pins here. Next you have dimensional accuracy or tolerance. A given feature can increase by around 0.5 millimeter. So you need to compensate for this and make sure eventually these are the design rules which we require to follow.

So in case if you have any doubt so I just need to look up on the net and I am sure you will be able to.

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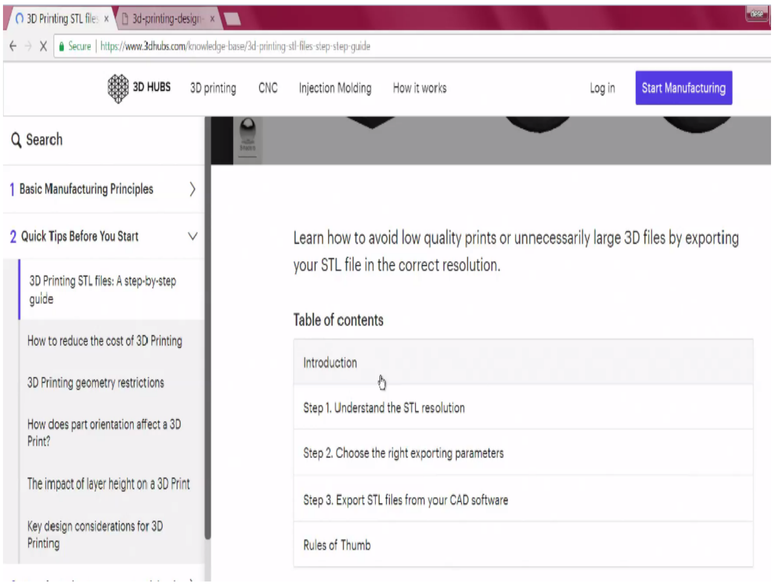

Invariably we need to generate what is called a STL file. This stereo lithography file is the one that learn how to avoid low quality prints or unnecessary large files by exporting in the correct resolution most important seems to be that saying.

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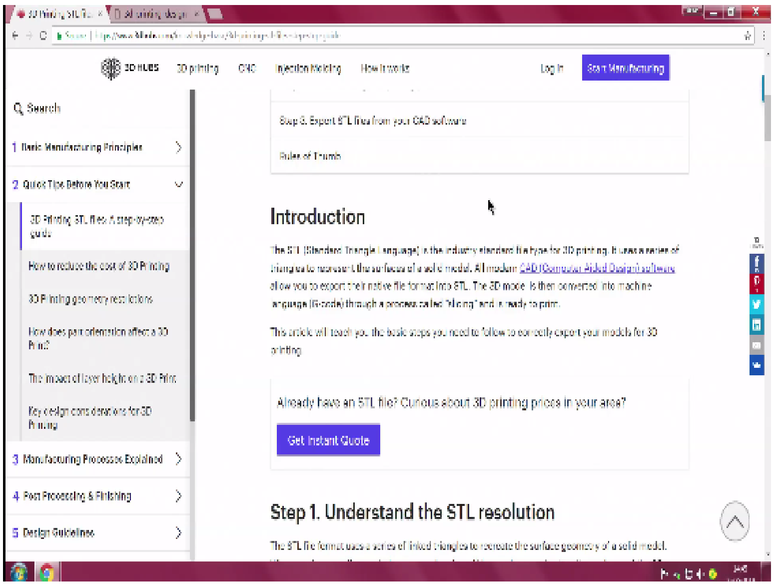

First of all, standard triangle language is a standard file type of 3D printing. It uses series of triangles to represent 3D. All modern CAD software allow you to export that native thing to these triangles which I have shown yesterday if you make a square hole the file is likely to be smaller. 3D model is then converted into machine language through a process called slicing the article we will teach you and so on.

So I suggest you go to the same 3D hubs knowledge base and finding out how these things work. I think you should read it yourself. My reading it on the screen will now help. I will spend more time and you can check and choose the exporting parameters.

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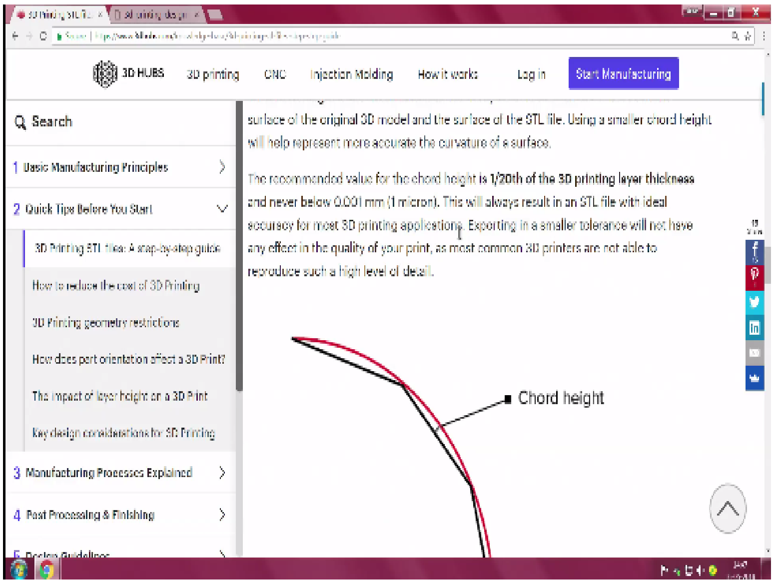

So usually the stuff about the recommended value for the thing is 120 out of the layer. So it should be here has given one micron and I will say even it should not be less than 10 microns. This will result in file which will deal accuracy for most 3D printing exporting in a smaller tolerance will not have any effect on the quality. So there is no problem.

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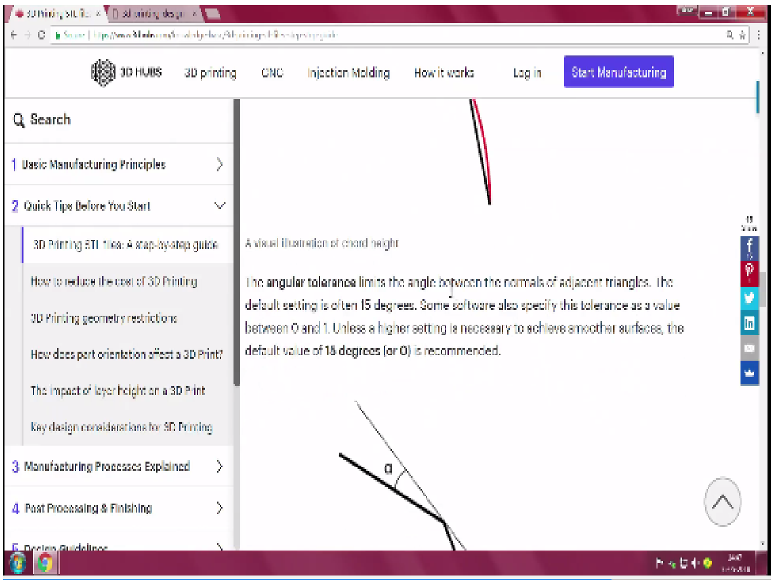

Then it comes to angular tolerance but in the normal.

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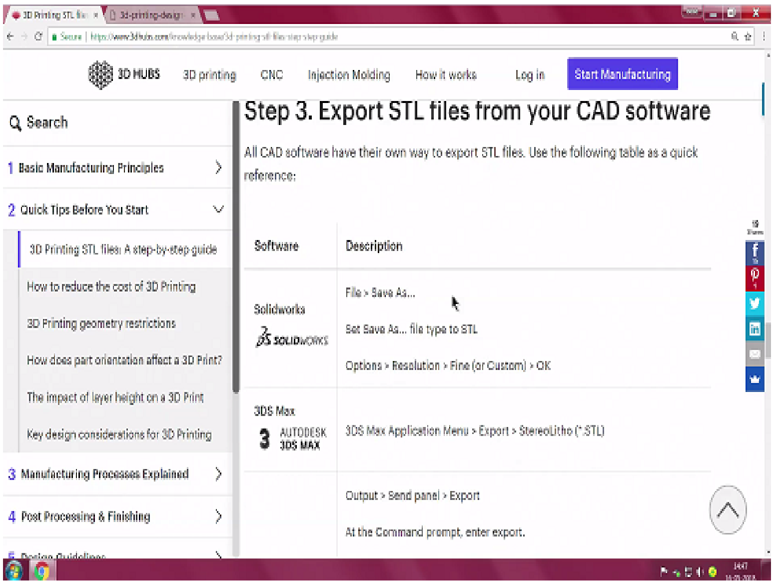

So exporting STL file from this thing often so he has given several of them including solidworks, save as then 3DS MAX.

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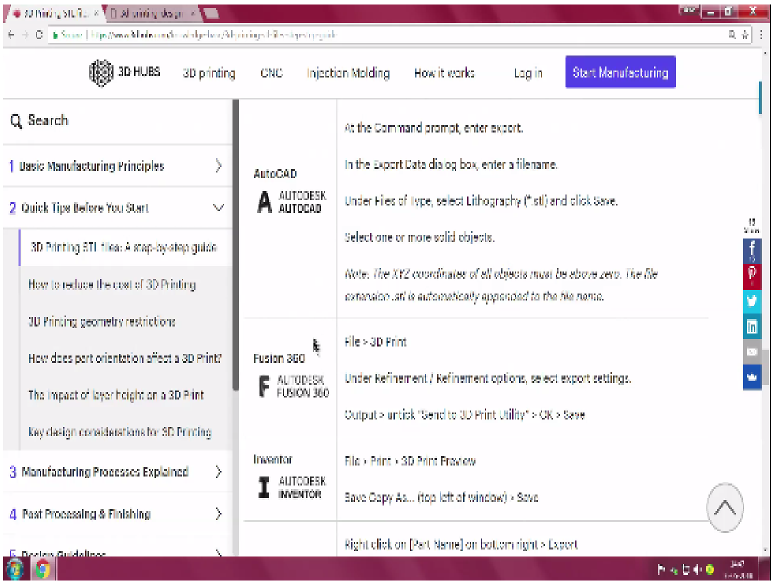

Then he has given Autodesks and then so many other thing including inventer then Onshape.

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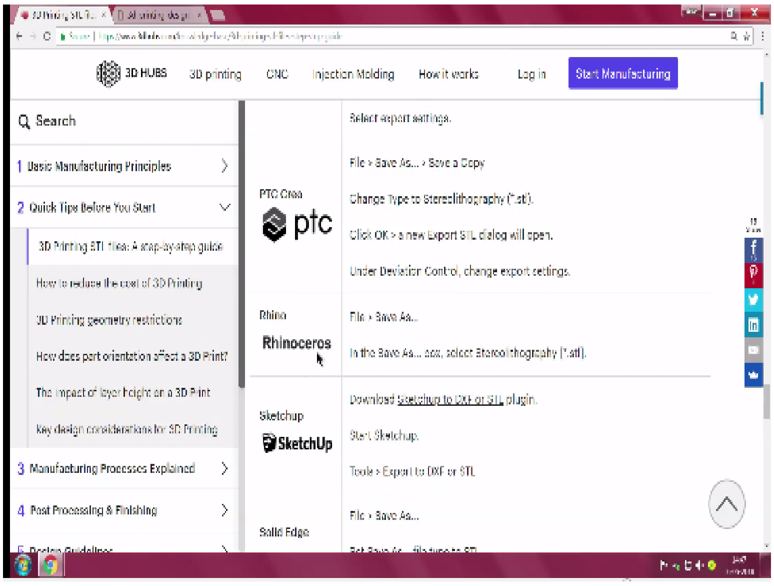

Then PTC then rhino. What I have been using is a what you call license for lecturer's stereo lithography file that is why I keep using the word stereo lithography file instead of the standard triangle that list what they have done. So I use this file then you have a sketch up I do not know if it is still valid. So right now you are likely to find solid works then some other related thing and then.

So we have lot of this stuff about you have seen this how this thing can be made. What is FDM, what does it work and all that. I suggest before I start explaining you read it. So both we have generically it is called fused deposition. Fused philament fabrication is a stuff which we have. FDM is mostly used 3D printing and hence the word printing has come.

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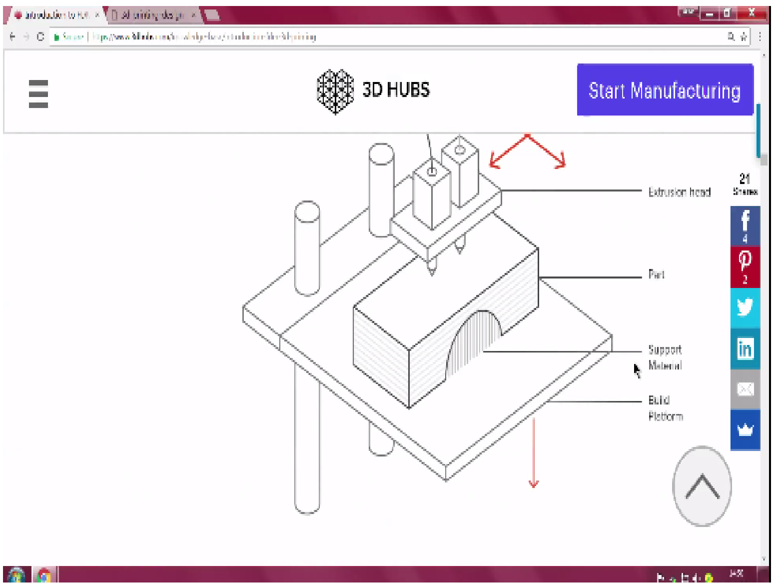

You see here at the bottom you have support material something supports at the bottom and then top that thing starts printing the actual objects. So we have here some of them have two types of material, some of them do not have two types of material instead it is (()) (28:31) material. A small thin this thing is printed which you will eventually be broken. So I suggest you know please read this thing.

So here you have seen this I will see if I can enlarge this and show you which I keep on what you call keep on mentioning again you see here at the bottom. You have the support material and on the top we have the part, but then if you look at the spacing here that is where they have given the thing about what is bridge depending on the type of material and depending on the type of feature size (()) (29:23).

So I think I will leave it you to read the stuff about 3D printing which is given here. So other options are also given which allow me to go back. Now similarly other people who maintain this have given huge amount of data on how to maintain these things. So what to do with surface normal and holes and open it just duplicate surfaces, hollowing parts.

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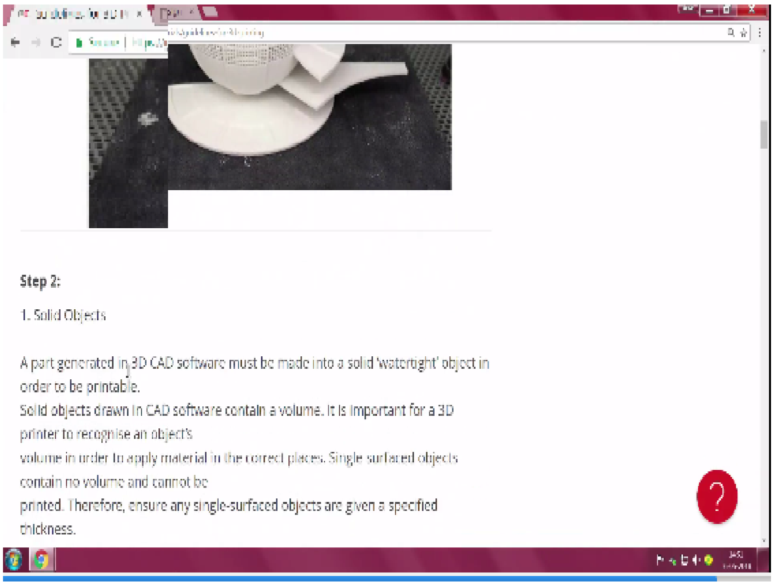

Bottom few references are given saying what could be a duplicated edge.

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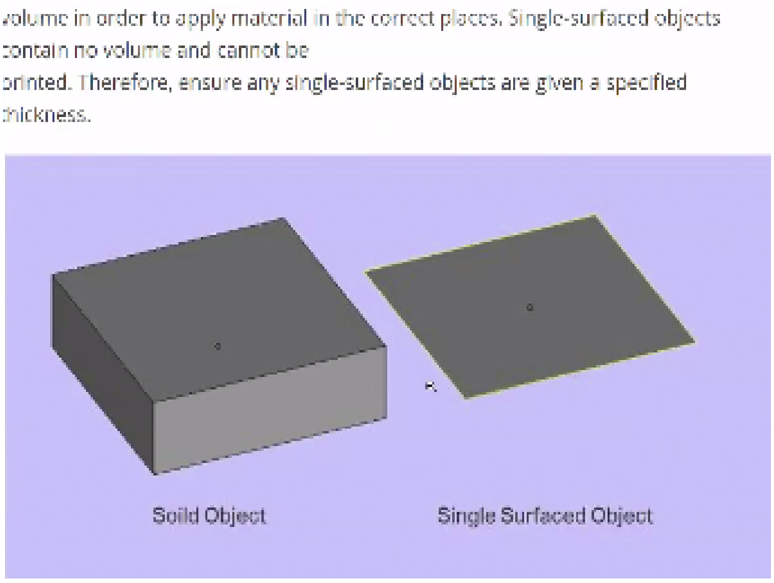

This is solid object this is surface object. So you have to be very, very careful on how do you play with these objects.

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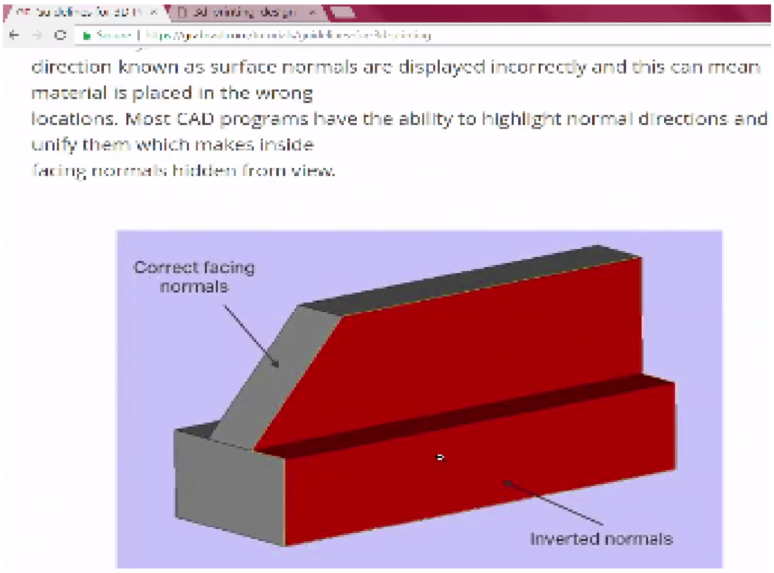

Then what is a normal direction. This is an inverted normal. You see here there may be a problem about how these things build and you have seen this here if you see carefully.

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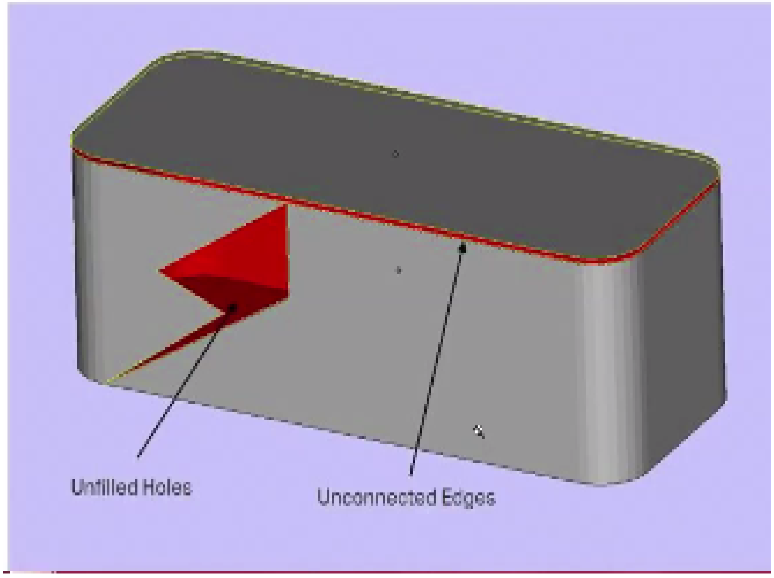

Some problem has happened here. There is an unfilled hole if you remember yesterday when I was trying to fill at the corner this thing happened. Then there are you need to make sure that these opening and all are completely covered that there is no error. Most of the time the current 3D printing software helps you identify these things automatically and this happens to me often because of the various types of trying to build things.

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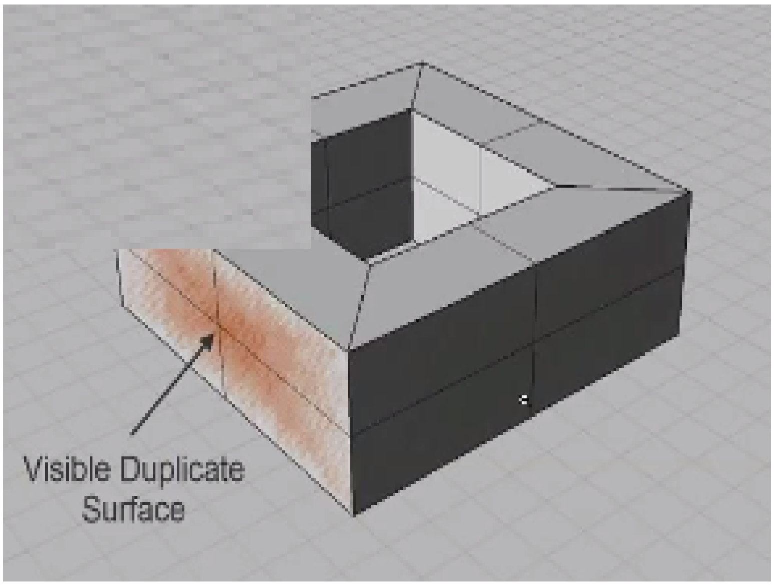

You see here I ended up with a visible duplicate surface. So I do the easy way out. I select what I want export it to different file and try to manipulate the file on the outside. So we have here saying sizes of the details.

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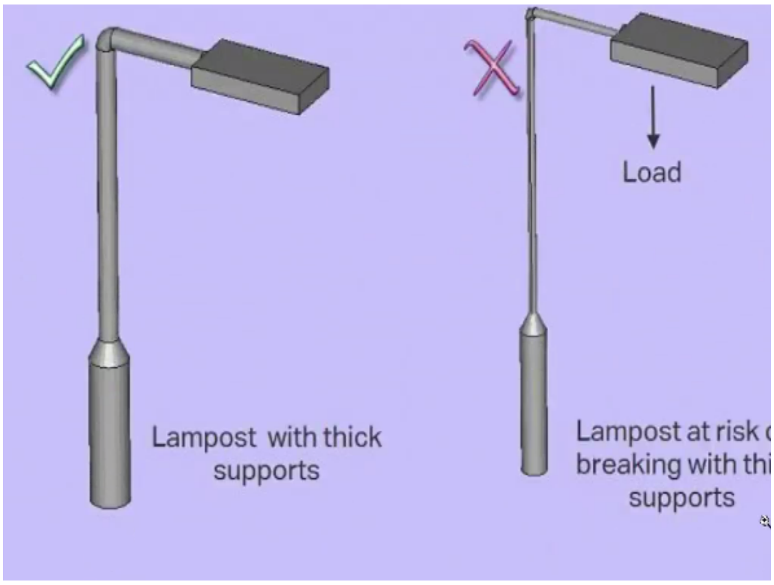

See here lot of thing has been build inside in spite of this steps and all that. They are trying to make it by making this particular thing why it looks so small it is not a real lampost this is made for a model railway. So you have that 9 mm then you have (()) (32:19) then you have standard model trains. So somebody has spent a lot of thing and probably printed it at home.

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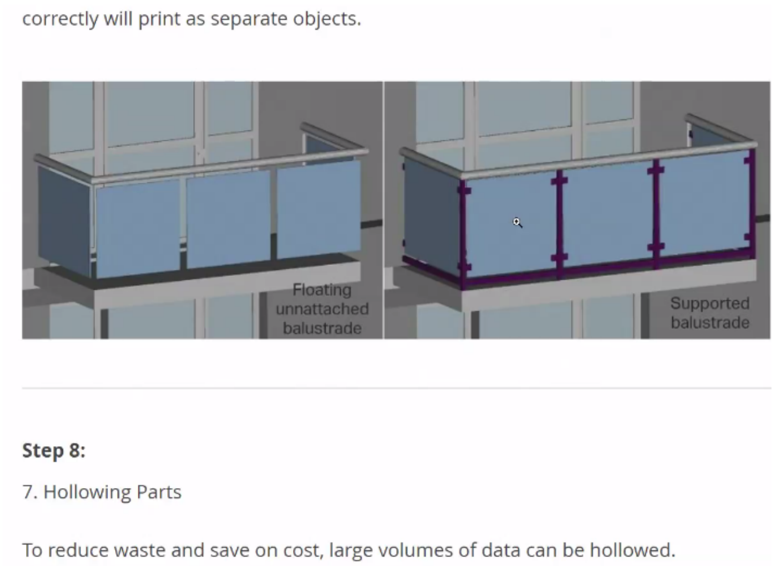

And you see here if you see 2 objects here for example this is probably part of an architectural model. So when you build a house you need to make an architectural model, it is not easy for us to print all the features and I would rather use a combination of (()) (32:44) and these other things for railing inside all that we can do. In this case this is a railing with glass panels.

So left is what the model has been made because it looks interesting and probably it is traced from an available thing, but the reality is these such thing cannot hang on in the air. So instead as in real life you need to have these connectors which will ensure that the objects stay in place they cannot be in the air.

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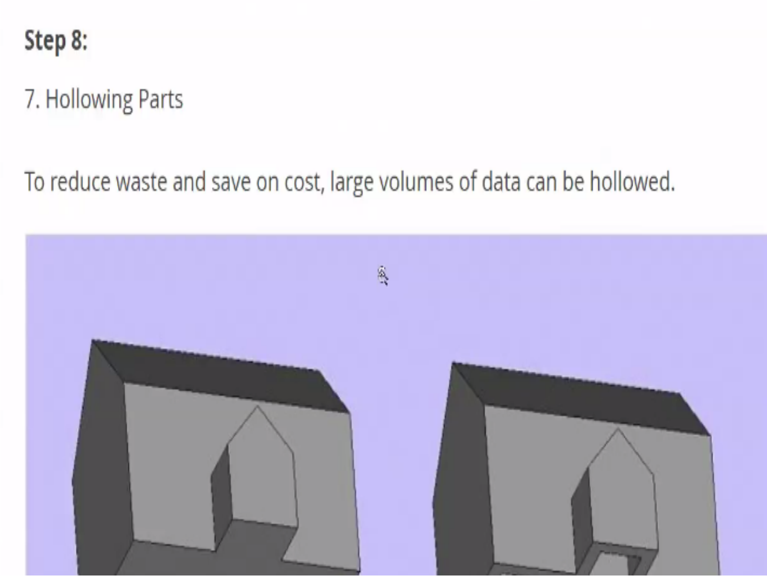

To reduce waste and save on cost large volume of parts can be made hollow. So this also probably was part of the exercise then how to build things and all that and now we have stuff about one way of producing large prints that exceed a 3D printer build envelope is to split the data into 3 sections. Print them and join the sections together post printing. If you see this is the house.

This house has been made into it is a left part, right part and the middle part have been cut here. So that is one here you have left and you have right and typically something which is about what you call 150 mm, 150 mm high is easy to print remaining is how much depended. So here you use see somebody has given a nice round up of how these things work. I think I will stop this lecture here. I will continue with the sample next.