Sensors and Actuators

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Lecture - 63
3D Printing Materials and Demonstrating of Remote 3D Printing

This module will be focusing on how to use the 3D-printing technique. Now, 3D printing as you know has evolved several tens of folds from the last few years and now it has been people are exploring you know the beauty of 3D printing into several different applications, right from automotive to medical devices.

On the same line, we will be also discussing on if there are two 3D printers right or let us say that if the 3D printer is in a remote location or other laboratory and you are placed in another laboratory; that means, can you access that particular 3D printer from a different place. Let me give an example. If my lab has 3D-printer which I keep it open for anyone to use and if you are in a particular college anywhere in the world, ok.

Can you operate my 3D printer through your place? So, we will be showing it to you how this remote operation can be done, how can use if the 3D printer model is in one particular lab or one particular place and you are located in some other particular place, ok.

So, that is the idea of showing you a little bit you know a little bit of advanced version of how to operate this 3D printer and I request one of my additive manufacturing guys to show it to you how this 3D printer can be utilized, right. So, I will request Sayed to discuss this 3D printer and take it over.

Hi all. Now, I will be speaking about 3D printing materials.

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So, here you can see a 3D printer and this is an FDM 3D printer as I have explained about FDM.

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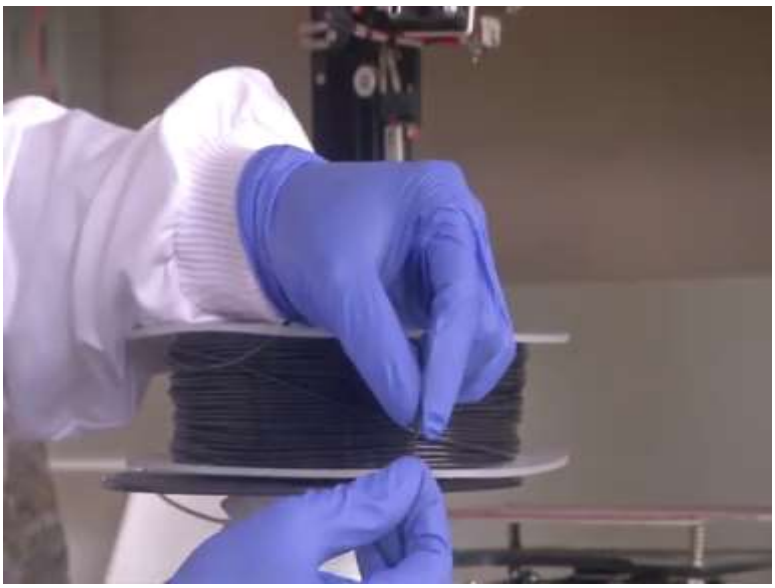

Here, there will be a filament, filament-like this filament is given through a heater and then it is coming through a nozzle and it is deposited on a platform. So, here I will be explaining about different 3D printing materials for FDM 3D printer. So, the first one is a PLA material, polylactic acid. So, this is an example of polylactic acid material.

Here the filament diameter is 1.75 mm, which is a standard diameter 1.75 mm and another standard is 3 mm, there, those that are the most used standard diameter for the filament in 3D printing in FDM 3D printing. So, PLA stands for polylactic acid this material is also biodegradable. So, it is having low costs and this is the widely most widely used 3D printing material. And the second one also, this also you can see this white color PLA material and this was a black color 3D printing material.

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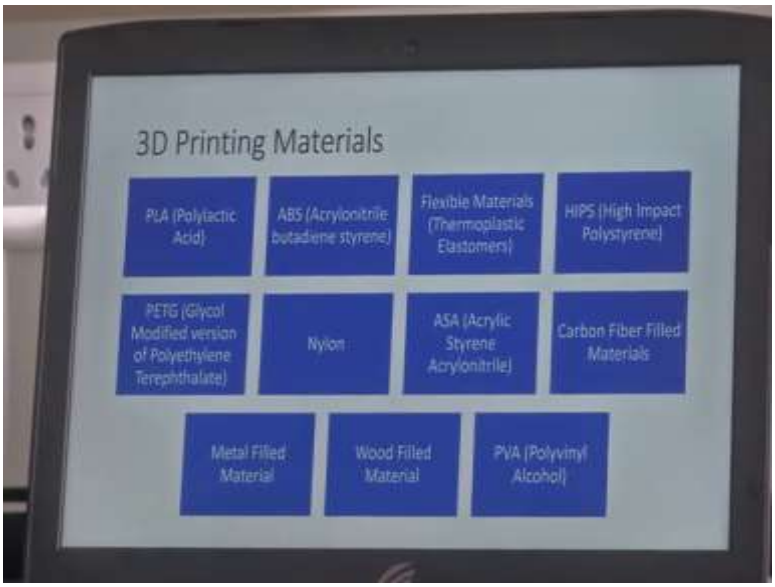

So, the next one is ABS that is acrylonitrile butadiene stearine that is also one of the widely used 3D printing materials. And ABS is stiffer than PLA material. So, for the application to require more stiffness and more strength people use ABS 3D printing material.

One major difference between PLA 3D printing and ABS 3D printing is for PLA 3D printing the printer does not need any heated bed; that means, there is a platform where the material is deposited. If we are using PLA material there should that there is no need for any heating in the printing platform, but for ABS that will shrink a little bit if it is cold rapidly, so that will need a heated 3D printing bed. And ABS is the cost wise that is similar to PLA.

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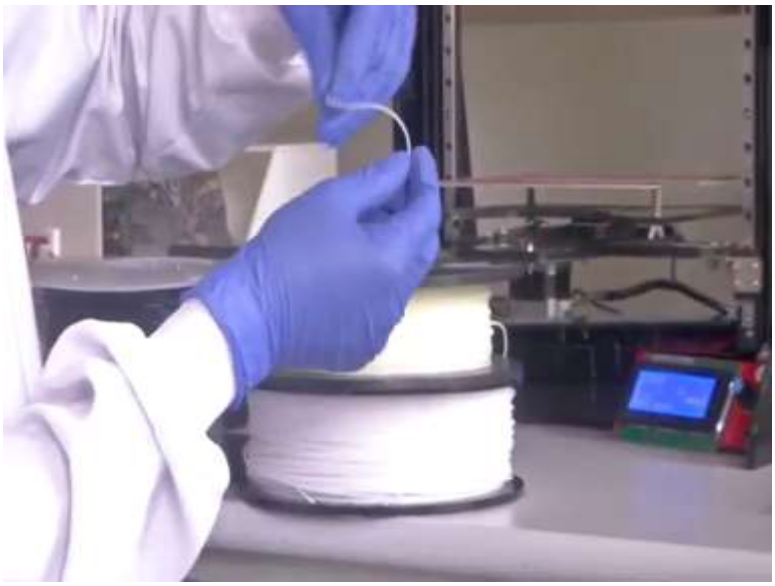

And next is flexible materials. Flexible material there are several materials. Here I have an example, thermoplastic elastomer elastomers. This is a thermoplastic elastomer material. Here you can see, this is very flexible and this material has one more specialty, this is a neon material, so this will glow in the dark. This can be used for making a structure that absorbs vibration or if you are; if you are making something need to be flexible or some connectors, we can use this kind of flexible material.

Next is here at HIPS, HIPS material that is high impact polystyrene. That material is mainly used along with ABS or it can be used by itself. If we have a dual extruder 3D printer, the 3D printer can extrude two materials or it has two extruders to separately extrude two materials and we can use ABS for printing the object and HIPS material for printing the support material. And one specialty is the HIPS material can be dissolved in a solvent.

Next is PETG that is a modified version of polyethylene terephthalate, that is, that is also people are used, but it is not wide as PLA or ABS.

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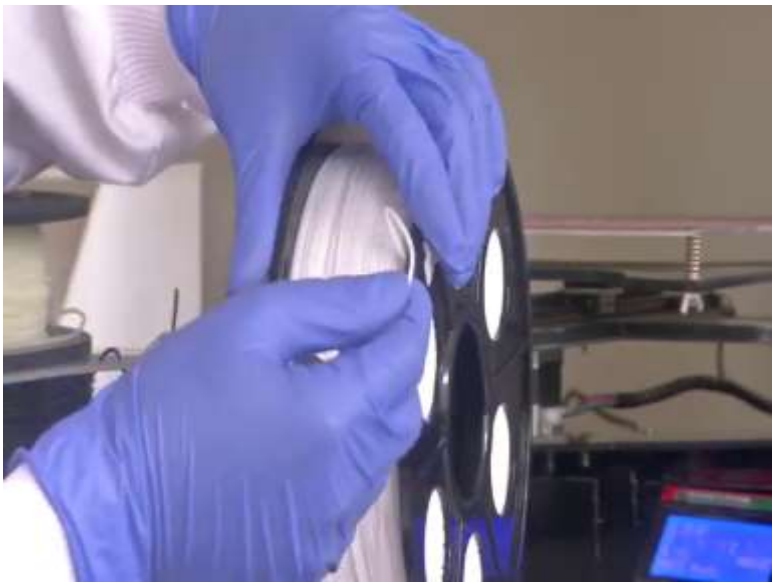

Next is nylon 3D printing material, here you can see this is comparatively flexible, but not as flexible as the flexible materials. Nylon material is mainly used for the application which needs high abrasion resistance, high impact resistant also. So, using this nylon material we can print objects like gears for gearbox etcetera.

And next is ASA acrylic styrene acrylate, which is also not widely used. The next one is carbon fiber-filled materials. Carbon fiber filled material means suppose this is a PLA material we need more strength, we need a material with more strength but the properties of the properties like the melting point of PLA. The manufacturer will take fine powder of carbon fiber and fill and mix it with PLA material to make this kind of filaments and the filaments will have higher strength compared to PLA, but less than carbon fiber alone.

So, the material will be filled with carbon fiber, carbon fiber fine particles. So, one the one upgrade we need for the 3D printer is while using carbon fiber material, the carbon fiber material is high abrasive, so the extruder we are using should be capable of carrying or extruding the carbon fiber-filled material.

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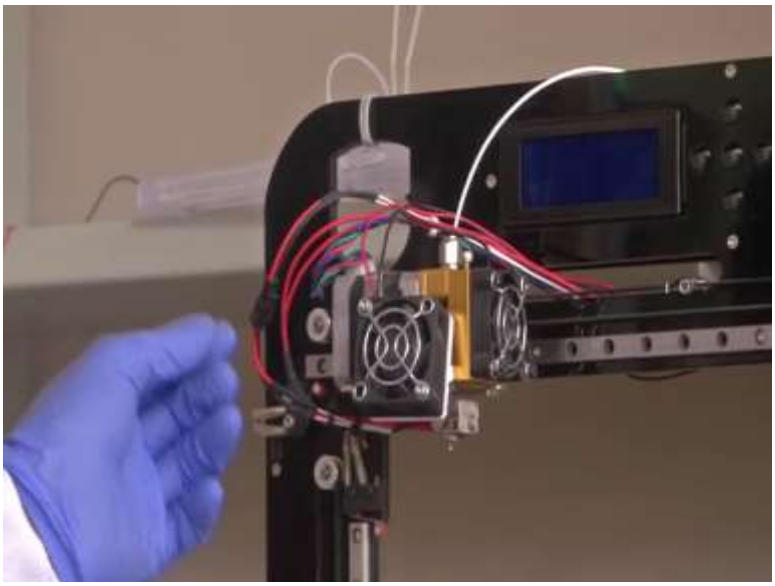

Here we are using a 0.4 mm brass extruder, but if you are using carbon fiber-filled material or other filling material the nozzle diameter can increase due to particle abrasion to the nozzle. And this will be similar to metal-filled material also. Metal filled material is mostly used for its unique finish, if you are using a metal-filled material the object finished will be very much similar to metal, but for printing using metal-filled material we have to change we have to upgrade the extruder for handling metal-filled material.

Wood filament material also similar to the carbon fiber or metal filled material. Fine particles of wood are infused in PLA or ABS material and can be used for making objects. Wood field material has one specialty like it can be easily sanded. So, using sandpaper we can easily sand the outer surface and make the finish look good. They would fill material, the appearance will be similar to wood material.

And the final is PVA polyvinyl alcohol. This is also not widely used, the most widely used are PLA and ABS, then flexible materials, nylon and HIPS or HIPS material or wood-filled material. In the cost vice PLA and ABS have the lower costs and the flexible material HIPS nylon as a carbon fiber-filled material, metal-filled material, wood-filled material and PVA those are of high costs.

And for ease easy printable PLA has the most advantage and if the carbon fiber-filled material or metal filled would filled material is the fine powder is mixed with PLA that is also easily printable. Easily printable means a 3D printer with a low specification can

print the print that. For printing ABS for thermal thermoplastic elastomers or nylon or any other, we may require a heated bed and for printing carbon fiber metal and wood, the filament will require upgraded extruder.

Now, I will show you how to convert a 3D object which we made in Autodesk inventor to a 3D printable file. There are several steps to convert from a 3D object to a 3D printable file. So, first we have to take the object and convert it to an STL file, then the STL file should be configured or converted to a 3D printable file or machine-readable file.

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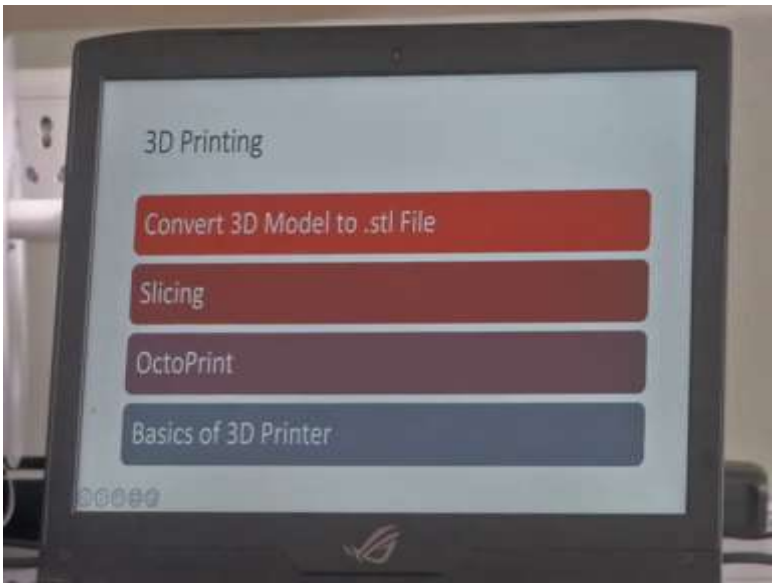

Now, I will explain about converting a 3D model to an STL file, then slicing that STL file for 3D printer, then I will explain a software called OctoPrint for the more 3D printing capability. Normally, a 3D printer will have and my a memory card slot or a USB slot or it can be connected directly to a PC. So, if it is directly connected to a PC we can operate the 3D printer using that PC, but the problem is supposed our printing needs around 24 hours. So, the PC also should be on at all times. If there is any interruption between the connection the 3D printing will pause and the or our time and the material will be lost.

So, another way of operating is using a USB pen drive or a memory card. In that case, we have to go near that 3D printer and insert the memory card or USB pen drive than have to start command give the command for start 3D printing. In this method using

OctoPrint, we can control the 3D printer using a web interface which is which can be controlled through the internet. So, we do not have to go near the 3D printer directly we can give the command for 3D printing from our PC which is at a remote location, then I will explain about a 3D printer and the basics of 3D printer.

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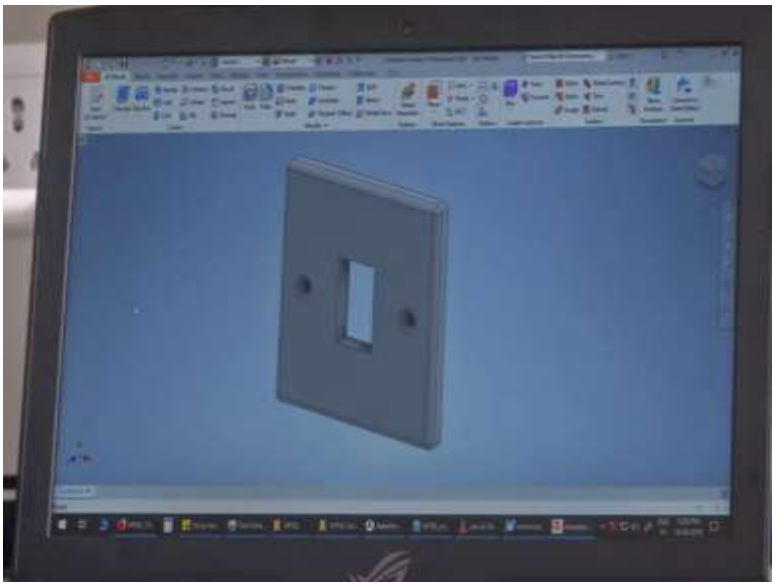

This is the object we made using Autodesk inventor. Here you can see this is the top part object. So, we want to convert this object to an STL file. Stl file is a vector file that is used for 3D printing in this Autodesk inventor software all objects are saved as IPT file. So, we have to convert this object in IPT format to a vector file. So, I have already opened the top part file, then I will go to files then I will go to print here, the print option, then I will select this sent to 3D print service.

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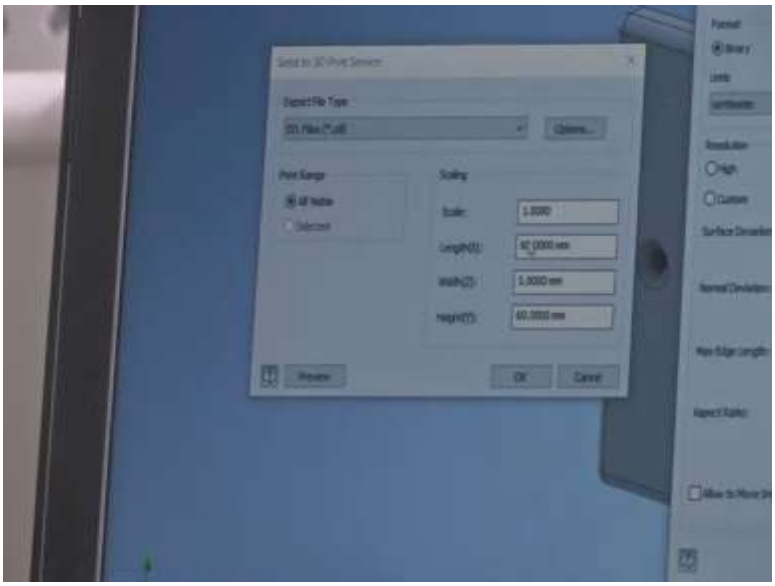

So, here you can see the length of the object was 60 mm as we discussed and the height was 60 mm the same height, these the length and this is the height and width was 5 mm. Width means the thickness, the thickness is 5 mm.

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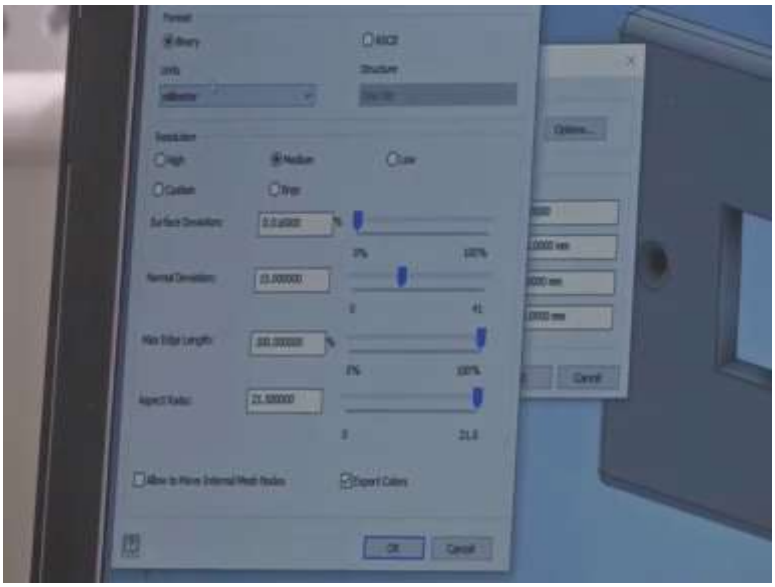

Now, one more thing we have to keep an eye on his click options. There is a; there is an option for units. Here we have to select millimeter. In STL file the there will be 60 and the object size and the object we have designed will be different. So, we have to select millimeter and click ok, I will click and I will select a location. This PC 3D objects.

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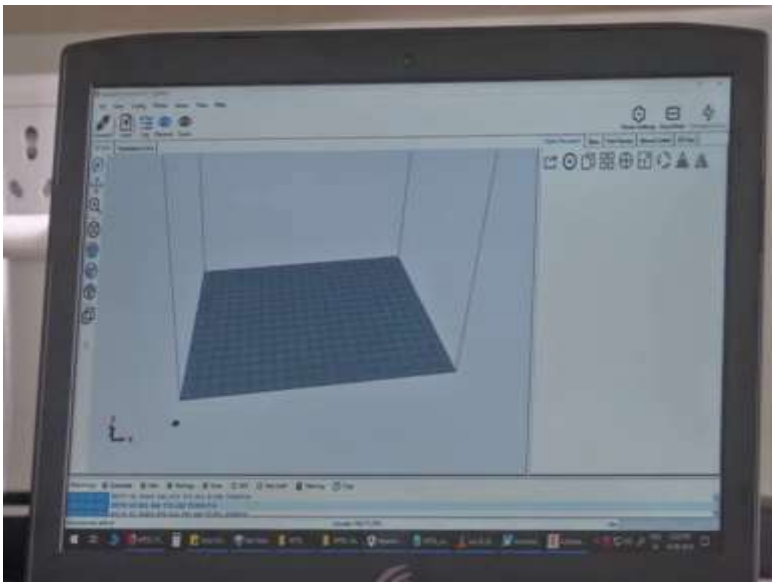

So, I will use software called Repetier.

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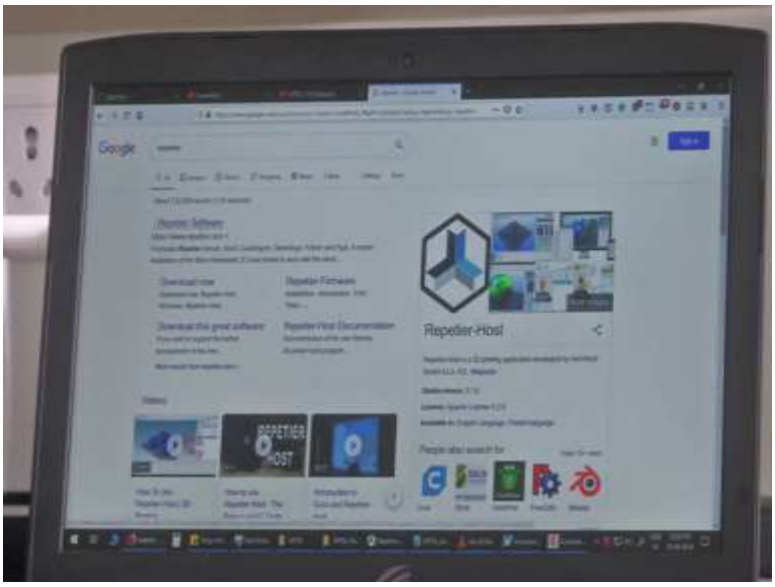

So, you can go to; you can go to Google and search for repetier. And the first link comes when we search for repetier, this the link.

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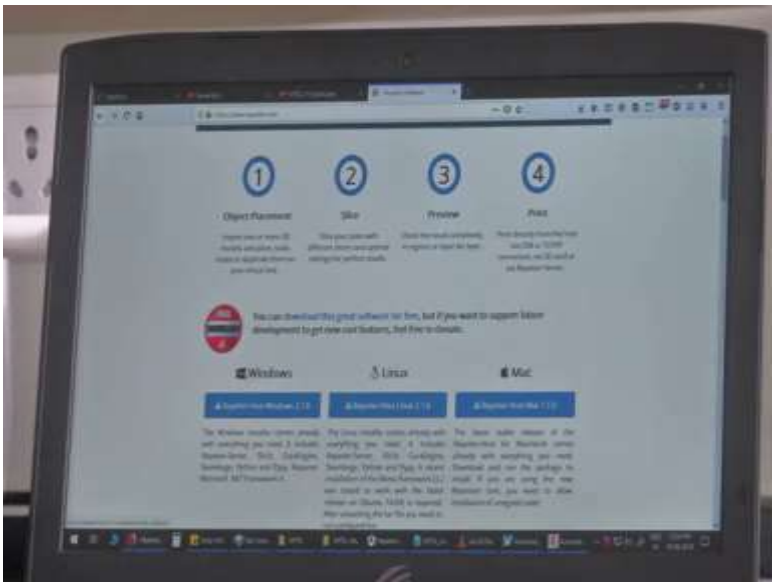

Here you can choose this button if you are using windows, if you are using Linux you can click here or if you are using Mac you can click here.

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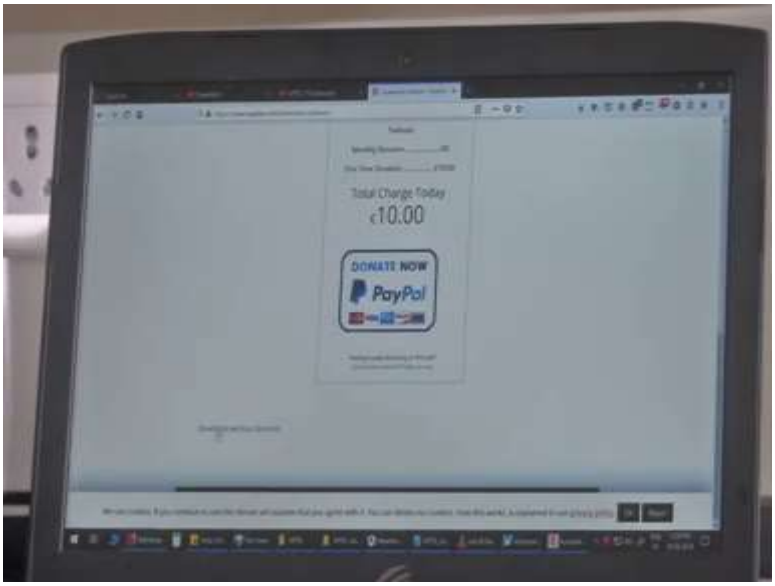

I will click here, and here there is a download without donation, I will click here and I will download here.

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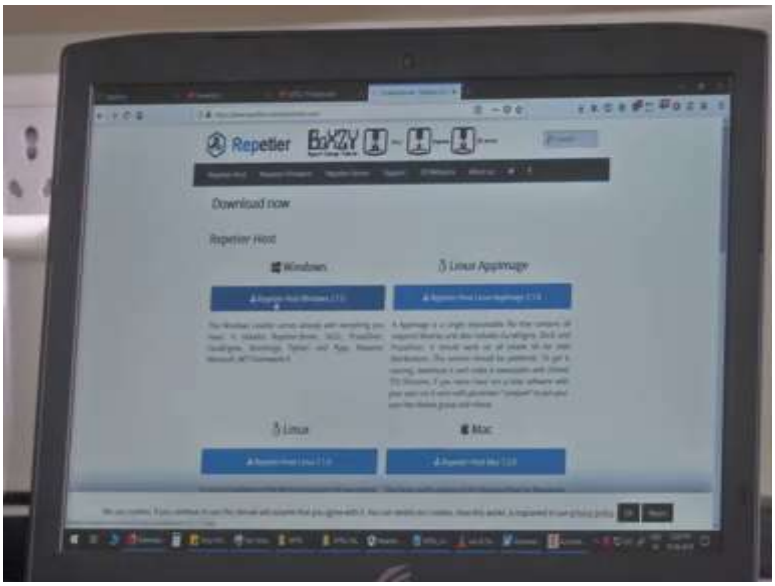

So, I have already installed it. This is for you to know how to download the Repetier software.

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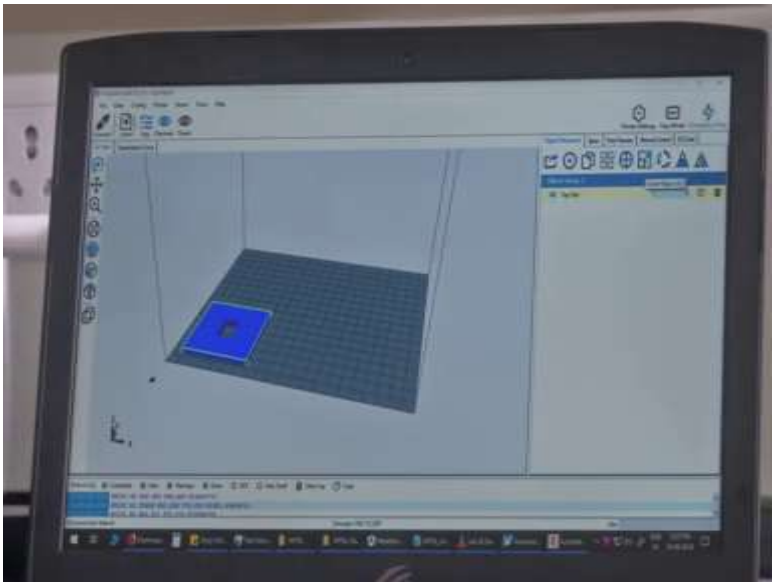

Here, these print volumes. I have configured this print volume for my 3D printer. This square you can see this the print volume and there is a dot here, this is the origin of the extruder. So, the length is around 170 centimeters, 170 millimeters and the width is around 20 centimeters.

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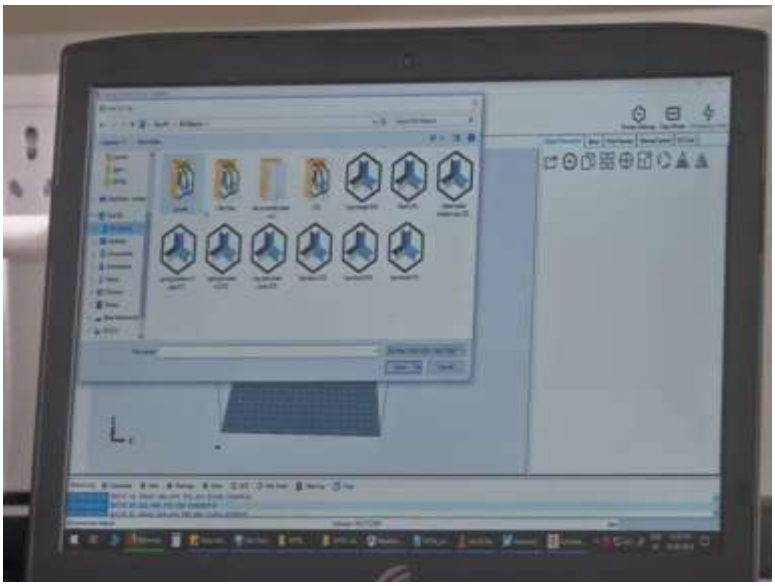

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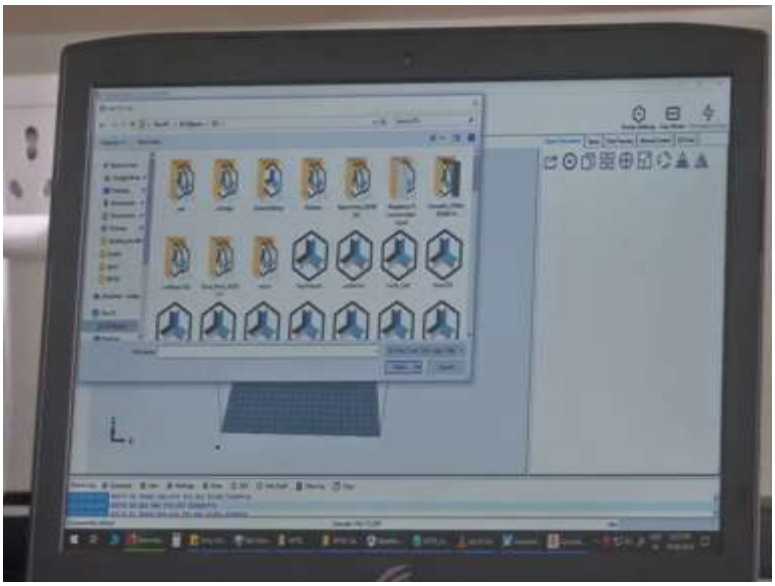

So, the object, there is an option for object basement, I will click add object and I am selecting the part, the file I have converted to STL file top part. So, here you can see in this software also you can use this scroll button to zoom in and zoom out and click the left button of your mouse to rotate the view or you can click on the roller, mouse roller and move more this view. Here I will place the object somewhere near the origin, inside the print volume. So, I will use the right button of my mouse and I will drag it here, drag it here somewhere near to the object.

And next is after the object placement, there are some other options also you can make copy objects. Suppose, you need this object then you can just click copy object and how many extra copies or object you want it will ask. I will just put it as one and click copy. See here there are two options, there is two objects. So, for I will just delete it and there is an option for rotating the object, there is an option for scaling the object or mirroring object.

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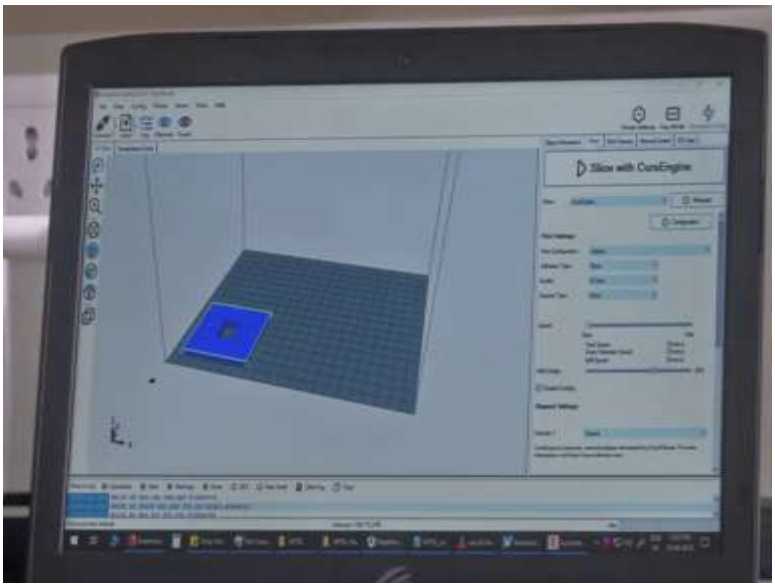

After placing the object, we are we have to go for slicing. Slicing means the object is slice by layer by layer and then it is converted to machine-readable code. Here we will be using G-codes the 3D printer is configured for the G-codes. So, this repetier software will give the output file as a G-code file that we can upload to the 3D printer.

Here in this slicer, we have some options for like adhesion type. If we are having any adhesion problem; that means, a plastic material suppose here we are using PLA material, it is heated and extruded through a hotted nozzle and these depositing on a plate. So, since they are different materials and there is a chance for note adhering the material on the build plate for that we can choose there is two options brim and rough. Here there is no adhesion problem, so I will click done and next is the quality.

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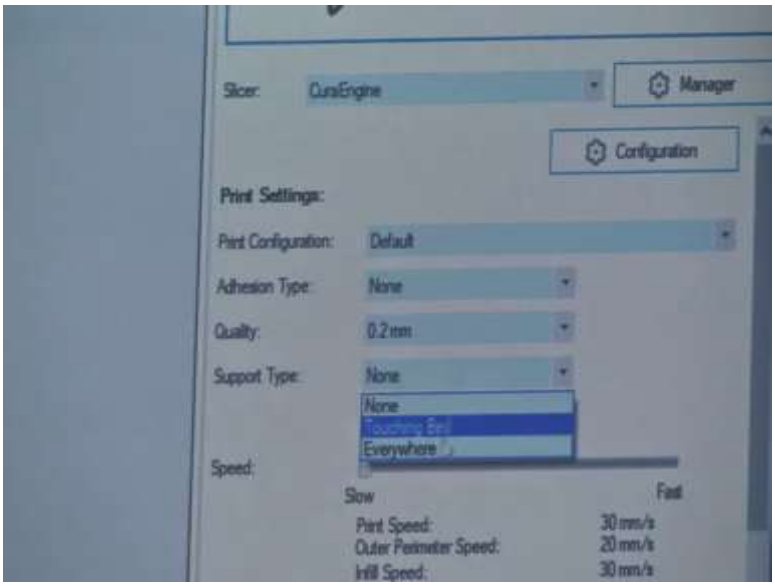

Quality means the height of each layer. Here the default option is 0.2 mm, which means 200 microns. This object will be sliced by 200 mm, 200 microns thickness and there are options for slicing at 150 microns or 100 microns. If you are giving it is as 200 microns the printing height the printing layer height will be 200 microns and we can see the object layer, the object layers which the 3D printer has deposited.

If we are if we want some fine smooth finished for the object we have to select better quality, but one trade-off is if we are selecting this 0.2 mm the time will be supposed it is aspects and if you are selecting 0.1 there will be 2 times less will be there for the same object. So, the total time taken will be 2 x. So, I will select 200 microns that will be enough for my application and support type. There are different type of two different types of supports.

For this object, there is no support is needed. So, I will click I will select it does none. And the speed of 3D printing, we can select different speeds this slows seed configured for this 3D printer is 30 mm per second and the fastest speed is 60 mm per second. I will choose 30 mm per second.

Another thing is we are making a 3D object. So, maybe our point of interest will be on the outside of the object, not the inside. And if it is not a functional part then we can we do not need material to be 100 percentage material. The object should not be 100 percentage material. So, we can give some air gap inside that to save some material, but

from the outside the material the object we have printed will look the same, but I will choose for my application, I will choose 15 percentage.

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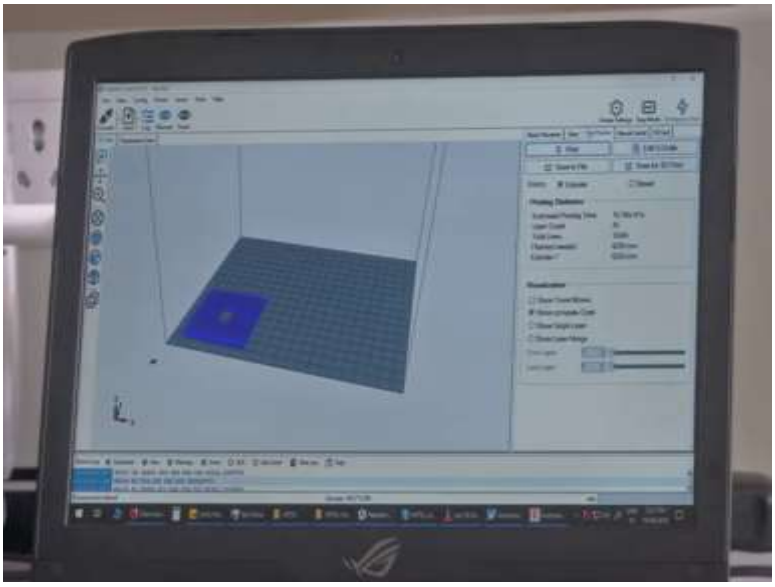

Then I will click slice with cura engine. Now, it has came to print preview.

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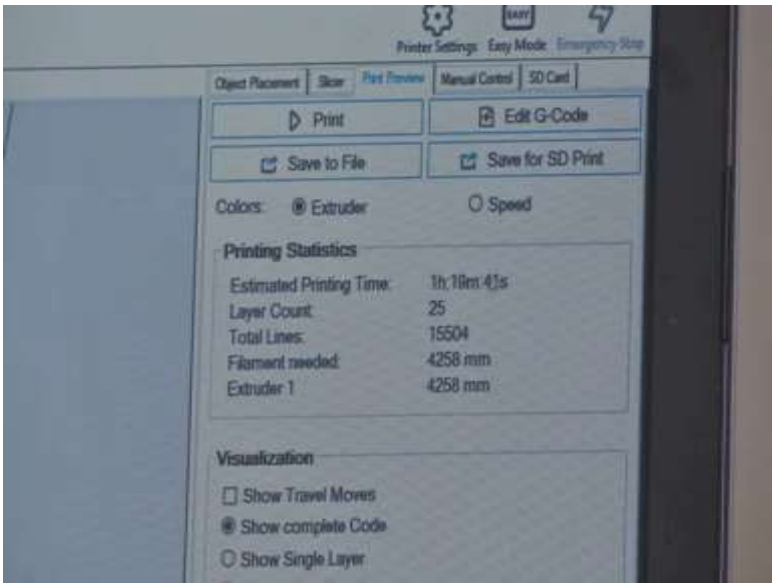

So, here in the printing statistics estimated a printing time. The estimated printing time is 1 hour 19 minutes and 41 seconds. The layer code the number of layers is 25 layers. So, we can just multiply 25 layers into 200 microns that we will get 5 mm and total lines the

filament needs that is also important this 3D printing will require 4258 mm of filaments. So, this is the 3D estimated printing time for 200-micron layer height.

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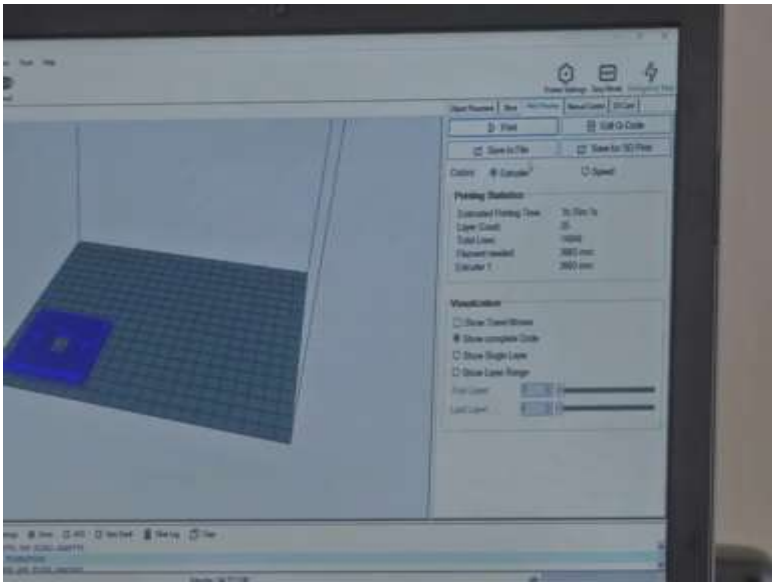

And I will show you 100 microns layer height. This almost double here you can see. The filament need will be revealed remain the same. I will go back and change it as 200 microns, and I will change infill density to show you. I will change infill density to 100 percent and I will slice it. Here you can see it require 6403 mm of filaments; that means, 6 meters and 40.3 centimeters. I will go back and change the infill density to 15 percentage and slice it.

So, I discuss with you about connecting a 3D printer to a PC. If you have connected to the 3D printer we can directly connect the 3D printer to this software using this button and you can click print here. But since we are not printing directly we have to save the file save the G-code file, here you can see the save as type it is a G-code file, the top file name is topper G-code. We will save it.

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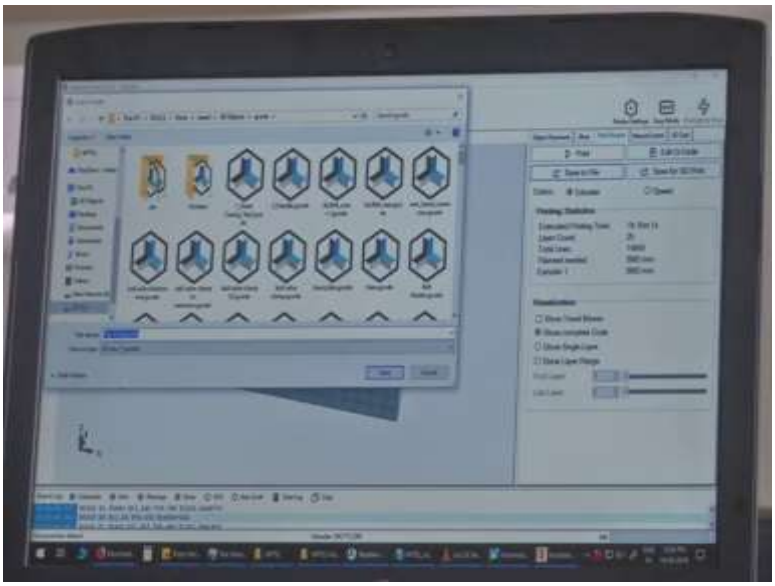

I already saved one that is why it is showing a confirmed. I will select yes.

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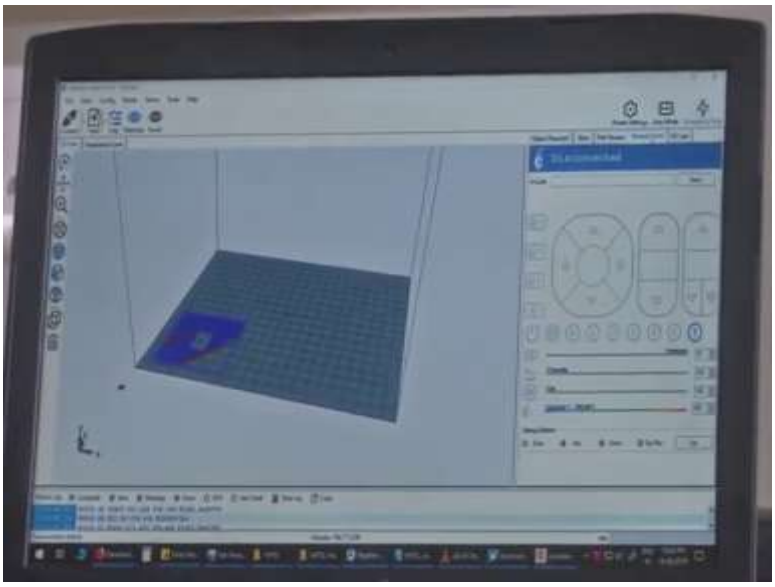

And if you have connected the 3D printer to this repetier software, there is manual control. Here you can see if there are some there are some options to control the 3D printer. We will be using OctoPrint software, so OctoPrint software will also have some functionalities. We can go through that.

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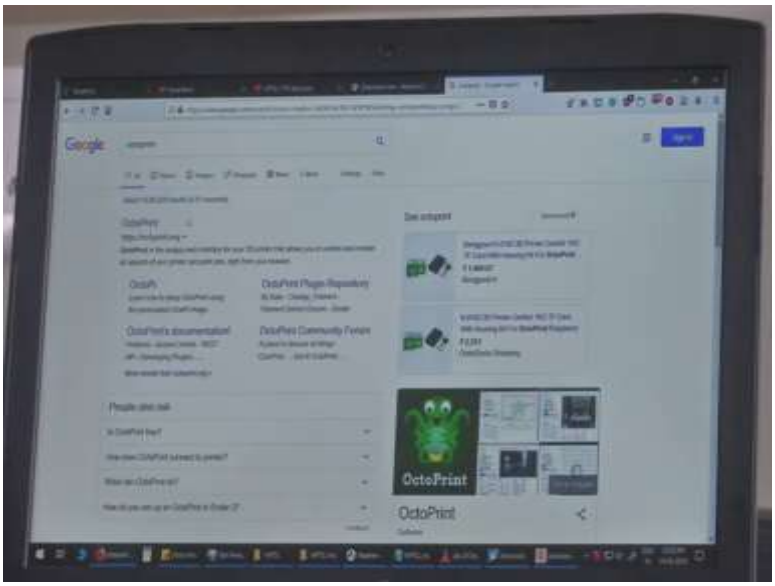

The software I am using is OctoPrint. We need a raspberry pi for running the 3D printer.

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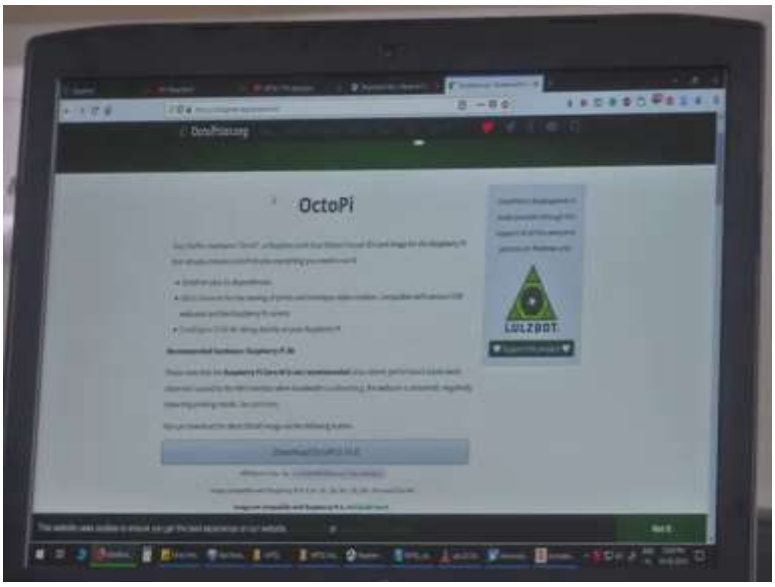

We can download the OctoPi operating system for raspberry pi from this OctoPrint.org website. And for installing this OctoPi OctoPi software we have to be we will require a new SD card or you can use an old SD card we have to, first we have to format that and using an operating system installing software we have to install the OctoPi software into a raspberry pi memory card.

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Here you can see this this is a raspberry pi. Here is the raspberry pi case, I will open this. See this is a raspberry pi 3 model, I have installed OctoPi into this and this is the power and this is the USB port for connecting 3D printer and I have connected this raspberry pi to using a LAN cable.

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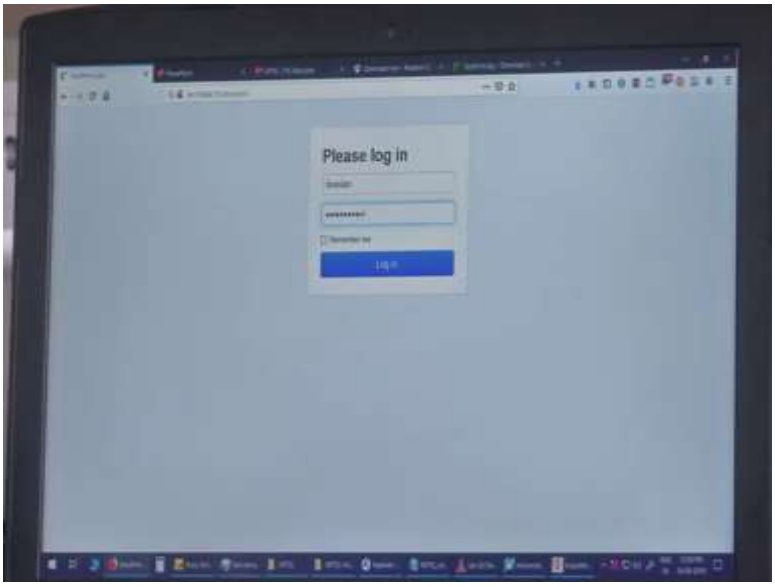

After installing the OctoPi software in raspberry pi, then we have connected raspberry pi to a LAN port. And the next step is we have to find out the IP address of the raspberry pi.

You can use any IP scanner. Here I will type my username and password. Username is beeslab.

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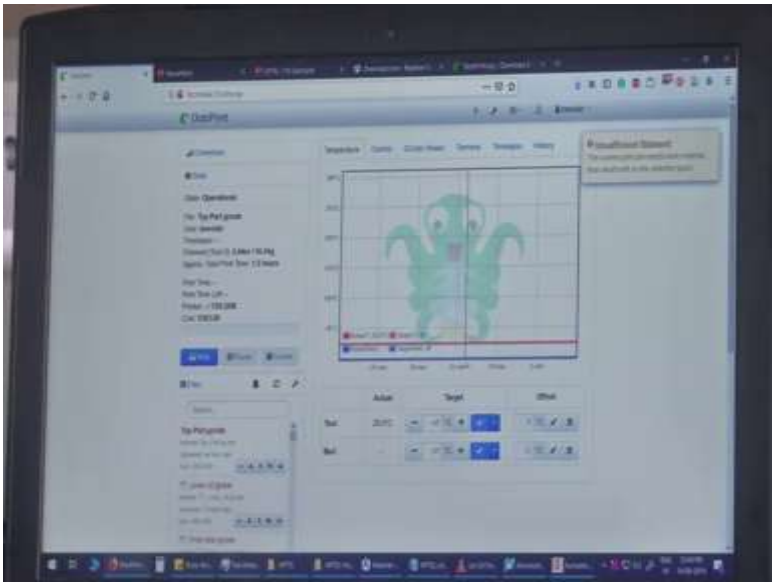

Here, see I got a; I got a screen with options to control the 3D printer. Here in this temperature tab, you can see the temperature. This red line is the actual temperature of the hot end or extruder. The blue line is the actual temperature of the bed. Here in this 3D printer, there is no heated bed, so we can avoid this blue line.

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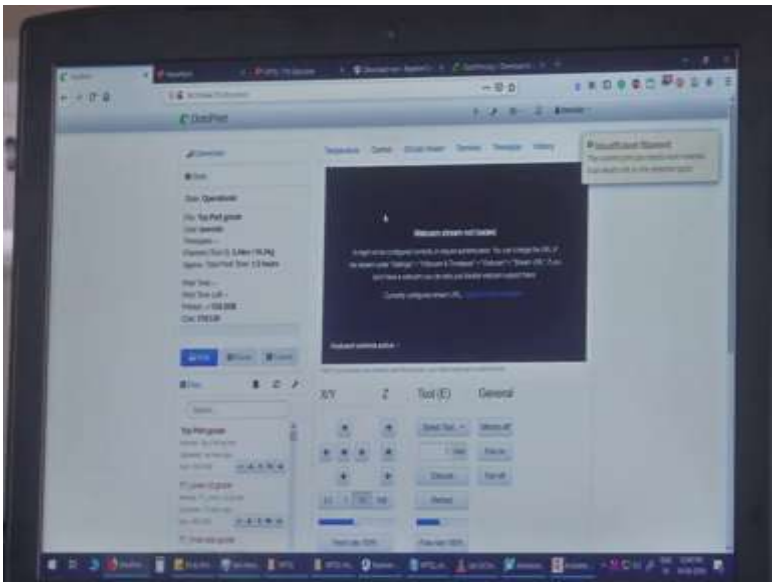
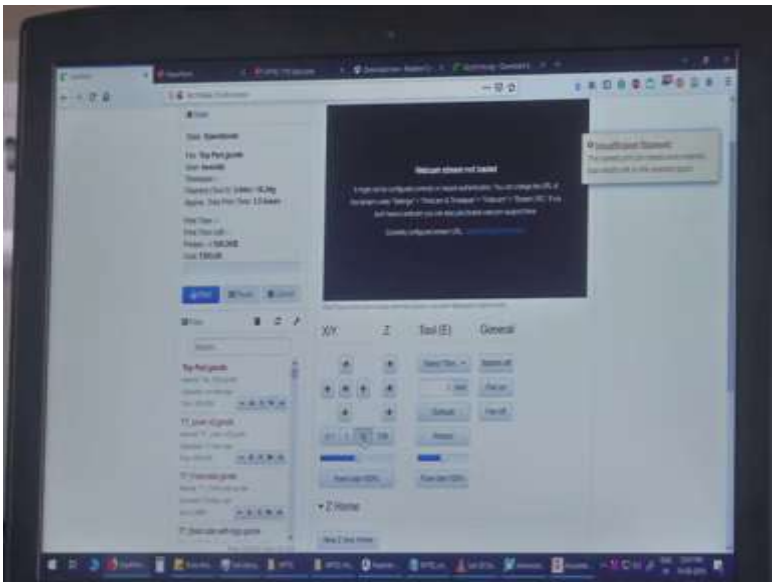


Next is in the control tab. Here webcam stream loading. You can connect a webcam to the raspberry pi using a USB cable and you can see what is happening in the 3D printer through this window. Currently, I have not installed a web camera and there is an option to move the x-axis or y-axis. Here to move x-axis towards the right side, this is moving x-axis towards the left side.

This is moving y-axis away from us and moving y-axis away from me moving y-axis towards me, this is a home button to the home x axis and y axis. Before starting any print the 3D printer has to go to his home position to calibrate then only it will start the 3D printing. This is for the moving z-axis.

(Refer Slide Time: 31:56)



And there are switches for turning on the fan, turning off fan and moving the x-axis at 10 mm at a time or to extrude retract and so on.

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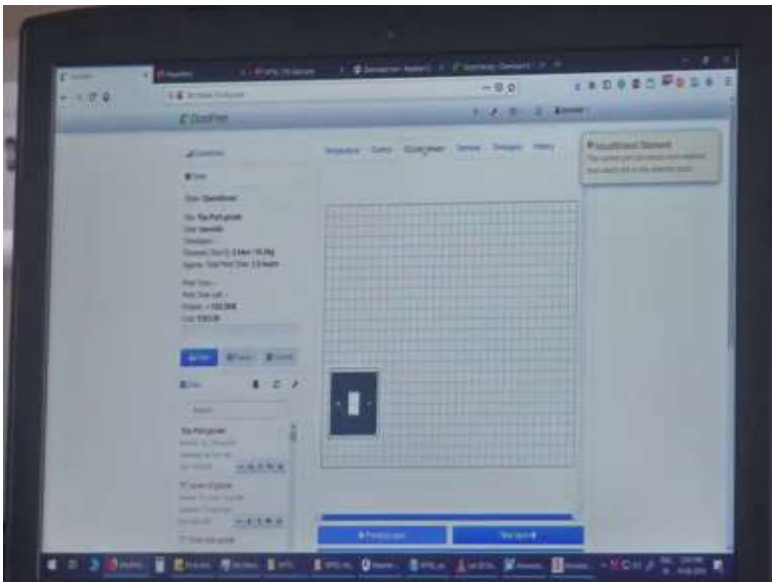
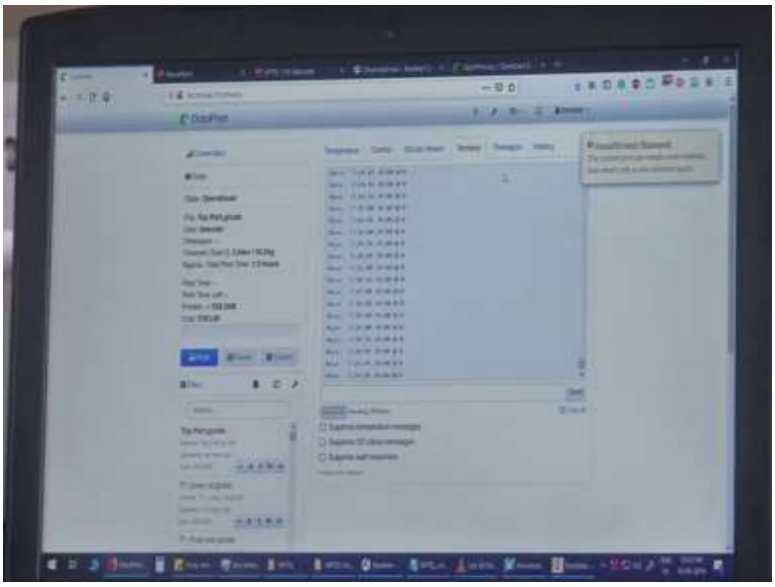


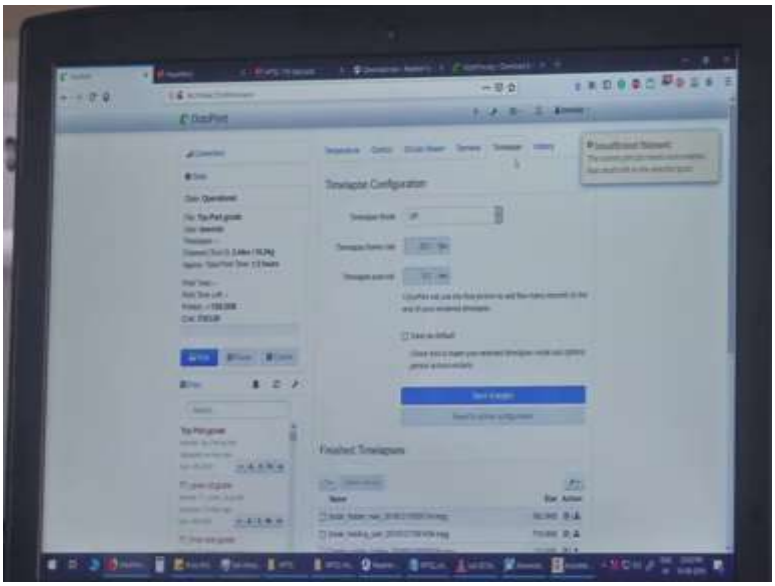
Next, there is a G-code viewer.

(Refer Slide Time: 32:20)



Next is terminal; if you want to intervene the actual G-code and you need something. You need to, if you need to put some G-code manually you can use this terminal window.

(Refer Slide Time: 32:35)



And there is provision for taking a time-lapse photo of the 3D printing object, we can use this. For using the time-lapse option, we have we need a webcam. And in this OctoPrint software, there are a lot of plugins to add. One plugin I have is a history plugin. So, I will know what all the things I have printed and how much filament is used for that printing time it took.

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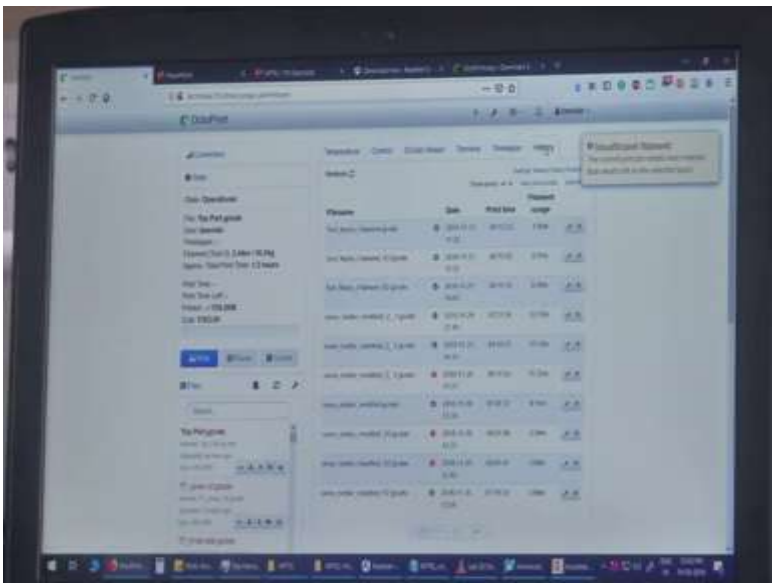

And another on another plugin I have installed is to calculate the cause is if, I here you can see the uploaded G-codes.

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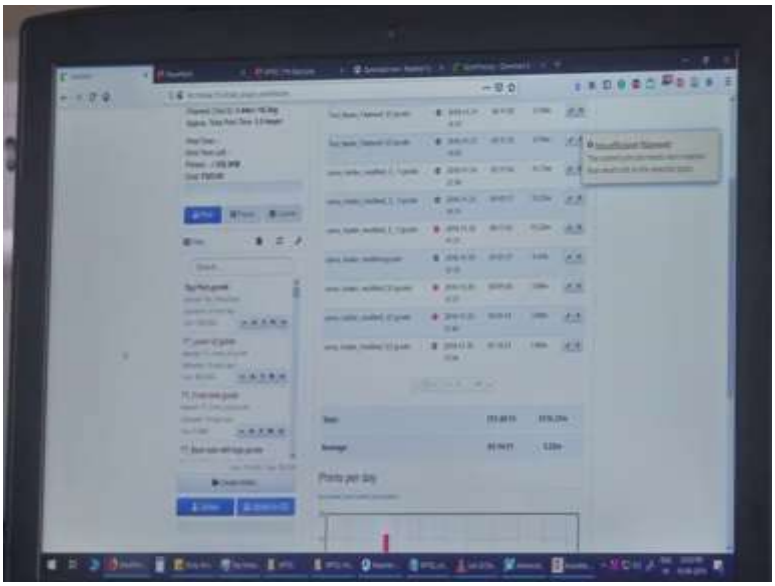

This is a top part G-code I have already uploaded. Here using this upload button we can upload G-code files.

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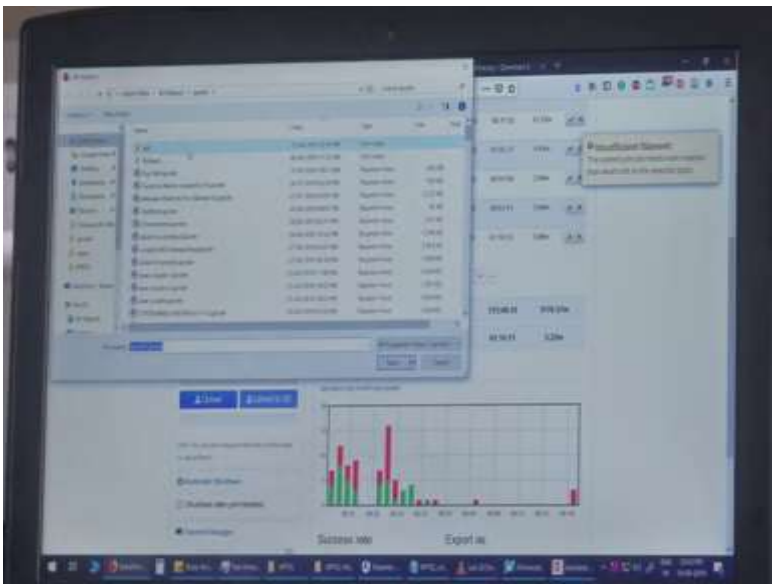

I am again uploading. This the top part called G-code. We can sort this as upload date and if we select it, it will show how much cost how much it will cause me to 3D print this. There is a formula in the back end. I have only included material costs that is why it is very low these 231 rupees.

First, I will select for 3D printing. First, I will select and then here is there are a load and print button I will click that. Before giving 3D printing, I will explain about my 3D printer here. Now, I will explain the different parts of the 3D printer we have in our lab. This is the printing head, it has two fans and this is the extruder. This is how the filament is fed into the extruder. There is a motor, stepper motor for extruding the filament and filament is kept on a roll here and this is the 3D printing bed.

This was the original display for the 3D printer we have customized for our purpose. So, this is the new screen for this 3D printer. There is a heater here inside, there is a heat sensor to know the exact temperature of the heater. And this is the nozzle, this is the x-axis left and right, the extruder will go left and right. And this is the 3D printer bed, this will go in y-axis towards and away from me and this is the is z-axis are combined.

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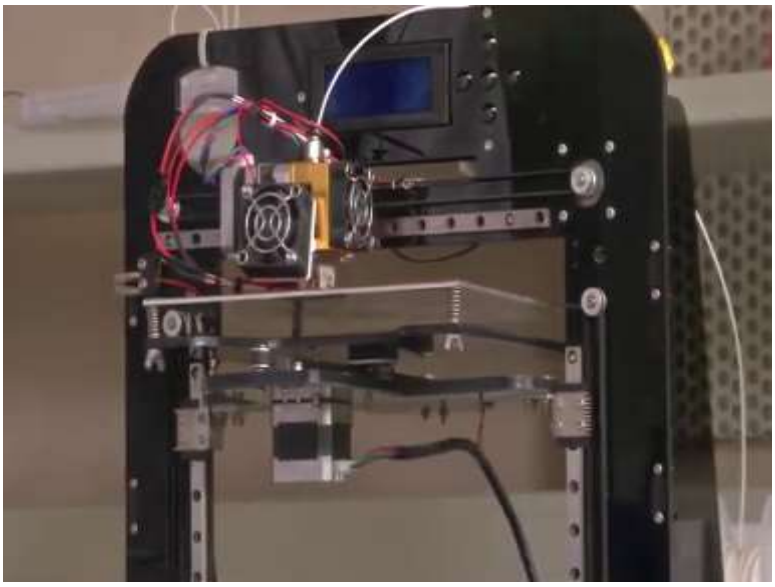

So, here the 3D printing bed is on the y-axis and the y-axis will move in an upward direction and the nozzle will only move in the x-direction. For moving in either direction there are two motors, one is here and one is here and there are linear gate rails for the precise moment in one axis there are linear rails gate rails in x, y, and z-axis.

Here you can see (Refer Time: 36:21), this is the limit switch or n steps which is used while calibrating the axes. Now, we can start 3D printing using this 3D printer. Now, we have selected this top part and I will click the load and print. I click the load and print. Now, you can see the x-axis has calibrated, now y axis is going, it is calibrated and the z-

axis is moving towards topside. It will take some time to reach the end stop switch; z-axis also calibrated.

Now, you can see here in this graph the right lane is at this point. The target temperature of the extruder e is now 205 degrees Celsius. Here you can see another line that is the actual temperature, now it is at 77 degrees, now 80, it is increasing. It will reach 205 degrees Celsius then the 3D printer will start 3D printing.

Now, the nozzle temperature is around 205 degrees Celsius. It has started. Here you can see the nozzle is moving along the lines which are defined in the machine course and it is extruding material like this. So, you can see.

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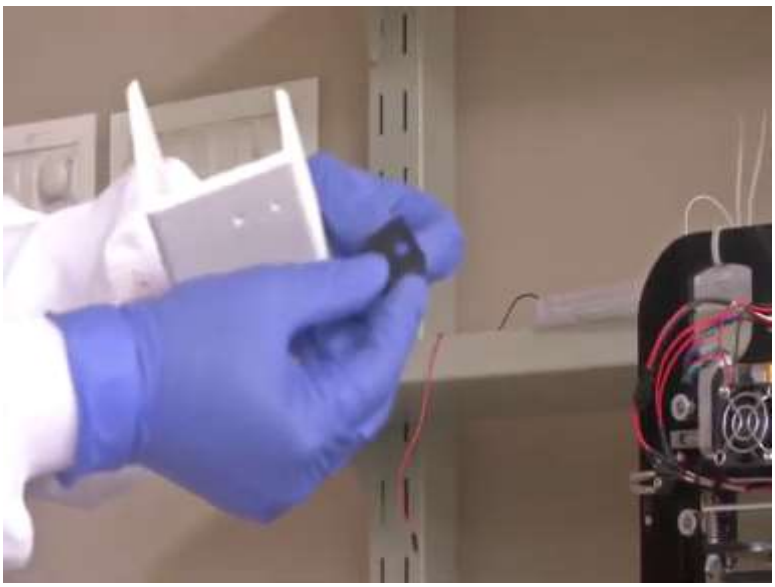

This is one model we have printed for our inner layer. This is for one another project and here this is a white color PLA material. Here you can see this is an object made using black color; black color PLA. Here you can see the layers and here also there are some lines. If you closely look the lines will be of 200 microns height.

Now, we can go back to the 3D printer. You can see it started making a rectangle in the center and two holes in the two sides. This 3D printing will take around, it will take more than an hour. So, we can see after the 3D printing finish.