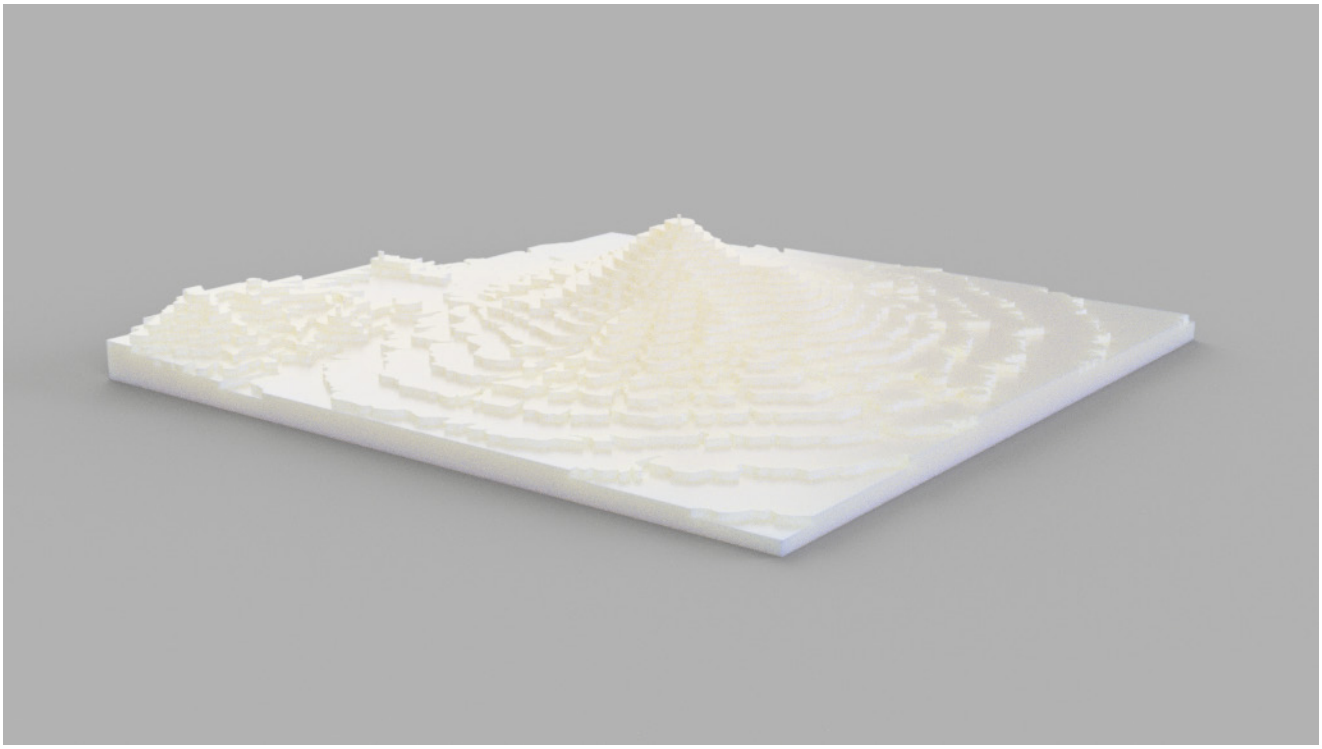

2D Map to 3D Model
Student Workbook

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1 Analyse your Contour Map

Take a look at the contour map image and work out the answers to the below questions as a class. You will need to zoom in to your image to be able to see the contours and contour labels.

a. What is the lowest 100m contour label on the entire map?

b. What is the highest 100m contour label on the entire map?

c. The real life length of your contour map is stated in the file name title. the map is split up into a series of equally sized squares. What is the real life length of one square section?

We need to work out the size and scale we want our contour model to be. On the next page we will run through various options before deciding on the scale we will use for the model.

2 Scale Calculations

a. We need to create a base elevation - this will be the base of our 3D contour model. We must determine it so that each student can calculate the distance to extrude their contours by. Take the lowest elevation on the whole contour map and make your base elevation 2 contours lower than this. E.g. If your lowest contour is 500m and you are using 100m intervals, your base elevation will be 300m. If necessary your base elevation can be a negative number. Write the base elevation down in the box below.

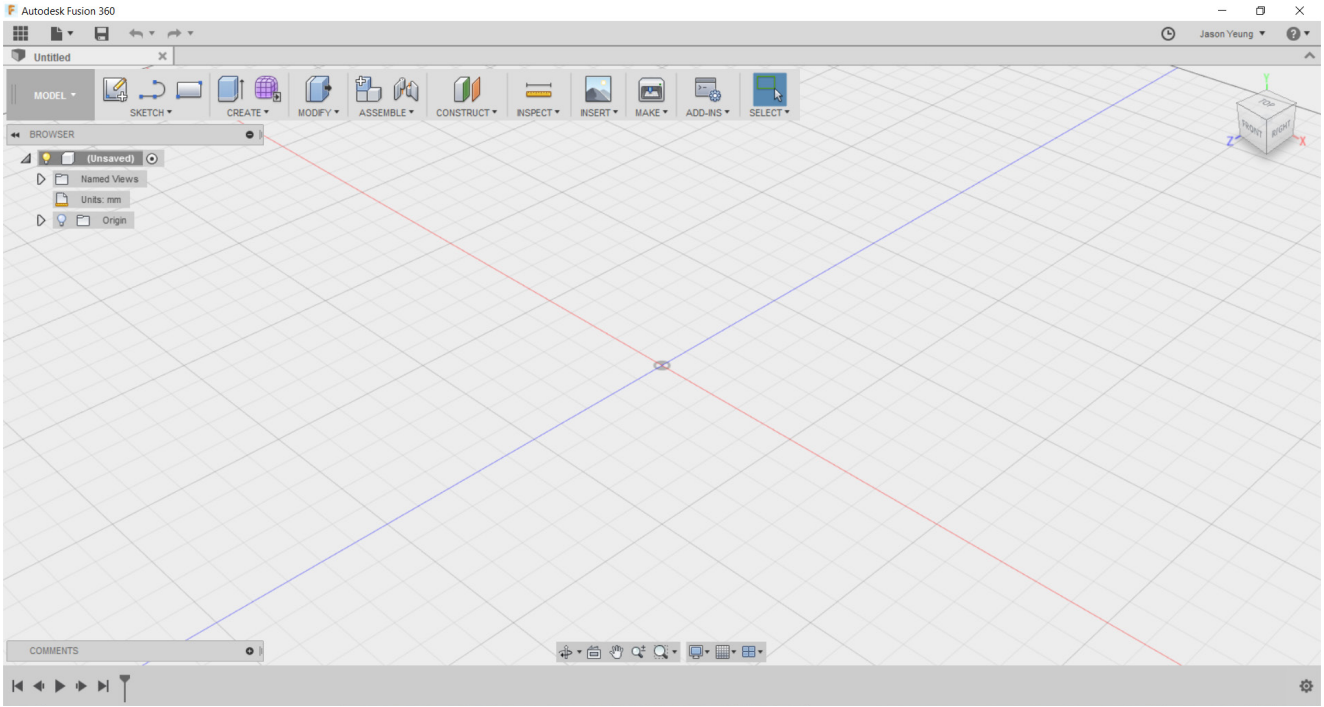
b. In the table below there are a range of common map scales. Using the values calculated on the previous page fill in the below table to help you decide the scale of the 3D contour model.

Scale	Length of model (m)	Total height of contours (m)
	Length of model = real life length / scale	Height = difference in height between highest elevation and base elevation/ scale
1:10,000		
1:25,000		
1:50,000		
1:100,000		
1:150,000		

c. As a class you now need to decide which of the above scales you will use for your 3D contour model. Discuss how big you want the 3D printed model and write the chosen scale down below.

3 Fusion 360 - Basic Navigation

You should have been allocated an area of the contour map to design. Open up Fusion 360 on your computer. We're now going to look at some basic navigation inside the software.



You should see a screen like the above image. Along the top, there are a series of menus that we'll look into shortly. Firstly, let's learn how to move around the workspace. Here are some basic navigation tools, give them a try!

a. Zoom in by hovering the cursor over the area you want to zoom to and scroll the mouse wheel downwards. To zoom out scroll upwards. If you prefer to zoom in by scrolling upwards, click on the drop down arrow at the top right next to your Fusion account name and go to preferences. Tick the "Reverse zoom direction" button then apply.

b. Hold down the scroll wheel button and move your cursor around. This will pan across the workspace.

c. You will notice a "view cube" in the top right. It will have labels such as "top" on it. Try clicking on different sides of the cube and the arrows and see what happens to the view. You can also click and drag the cube to orbit around. Click the "home" icon to go back to the main perspective view.

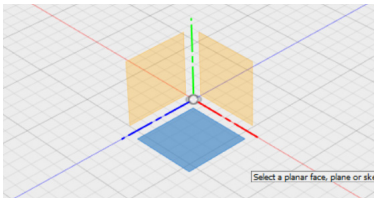
d. Hold down the Shift button on your keyboard and the scroll wheel button on your mouse. Then move your cursor around. This also orbits around the workspace.

4 Import your Image

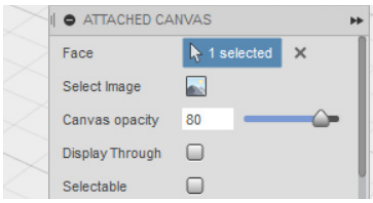
We now need to import the 2D contour map into our workspace so you can trace your allocated area. We will also calibrate the image so it is to the correct scale.

a. Navigate to the “insert” menu across the top row of icons and click on the arrow to view the options. Then click attached canvas.

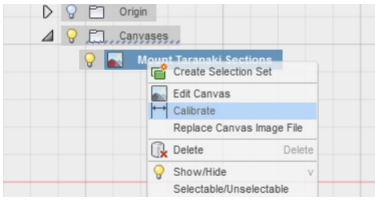
b. You will notice that 3 orange planes appear (you may have to zoom out/orbit to see them). They represent the x, y and z axes and you can select one of these planes to place your image on. Click on the bottom axis (the square between the blue and red lines). It will turn blue when selected like the image opposite.



c. In the “attached canvas” menu, click the image icon next to “select image” to choose your base image. Navigate to your contour map image and open it. You can also amend the opacity of your image, which can help when tracing over lines. Set the opacity in the “attached canvas” menu to 80 then click OK.



d. To finish off the canvas we need to calibrate the image so that it is to the correct scale. This means we’ll be drawing our model at the same size as we will 3D print it. Click the Top view on the view cube. On the left hand side of your screen you will see the label “canvasses”. Click the arrow next to this and the title of your contour map image will appear. Right click on the file name and then select calibrate. We need to pick two points on your image and state the dimensions we want it to be.

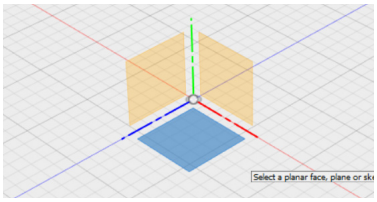


e. Zoom in to the square section that was allocated to you. Click on the top left corner of the square, then click again on the top right. In section 1c you worked out the scale and length of a square section. Type the length of a square in mm (x1000 to convert m to mm) then press enter on your keyboard. **In our example the real life length of a square is 3000m and we are using the scale 1:50000 so the length of one square for our model will be 3000/50000=0.06m = 60mm.

5 Trace Contours

Now you have your canvas in place, we're going to trace the contours to create surfaces that we can extrude. Remember to use the 100m contours only and not the minor (20m) contours.

a. Click sketch > create sketch. You will notice the 3 orange planes appear again. We need to select the plane we want to sketch on. Click the bottom axis (the same plane as your canvas is on). You may need to zoom out/orbit to see the orange planes.

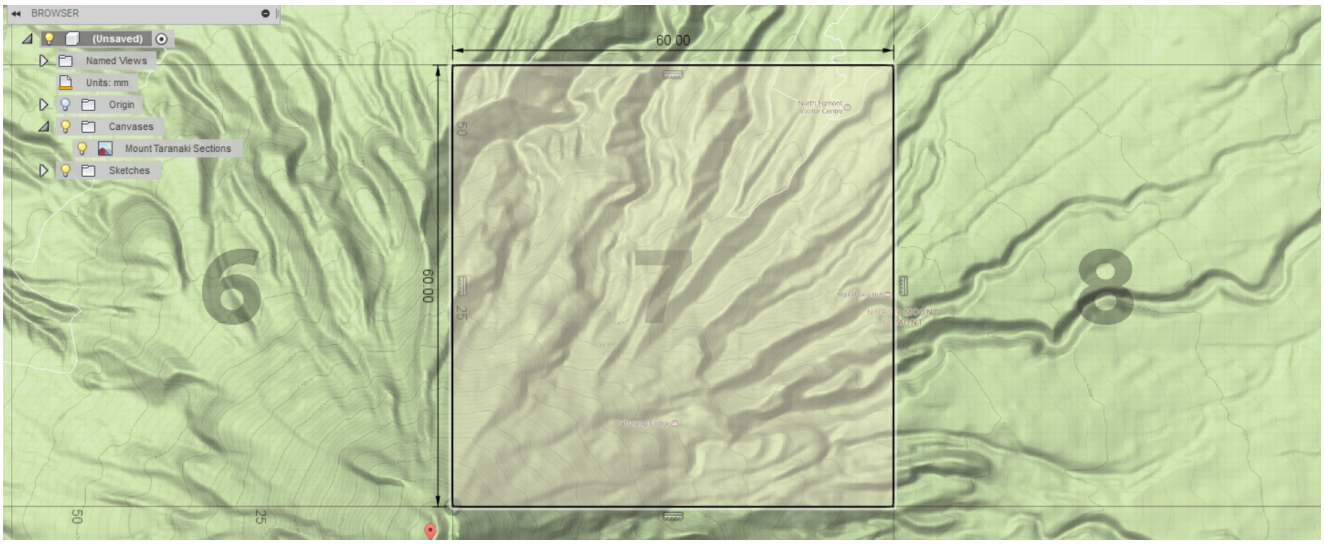


b. For this section you want to work in "top" view. Zoom in to your allocated section - we are going to trace the outer square to begin with. At the bottom and centre of your screen you will see a grid icon that says "grids and snaps" when you hover over it. Click on it and make sure "snap to grid" is deselected.

c. Click sketch > rectangle > 2-point rectangle. Zoom in and click on the top left corner of your allocated section. Start to drag out your rectangle and you will notice 2 measurement boxes appear stating the length and width of your rectangle. At this point you can type in the first length value. This will be your answer to 1c divided by the scale you have chosen. Remember to convert the answer from m to mm by multiplying by 1000. Once you have entered the first value, press tab on your keyboard and enter the second value (this will be the same value as the first). To finish you rectangle press enter.

TIP: To delete an object or line make sure tools are deactivated by pressing esc on your keyboard. Then click on the object to select it and press delete on your keyboard.

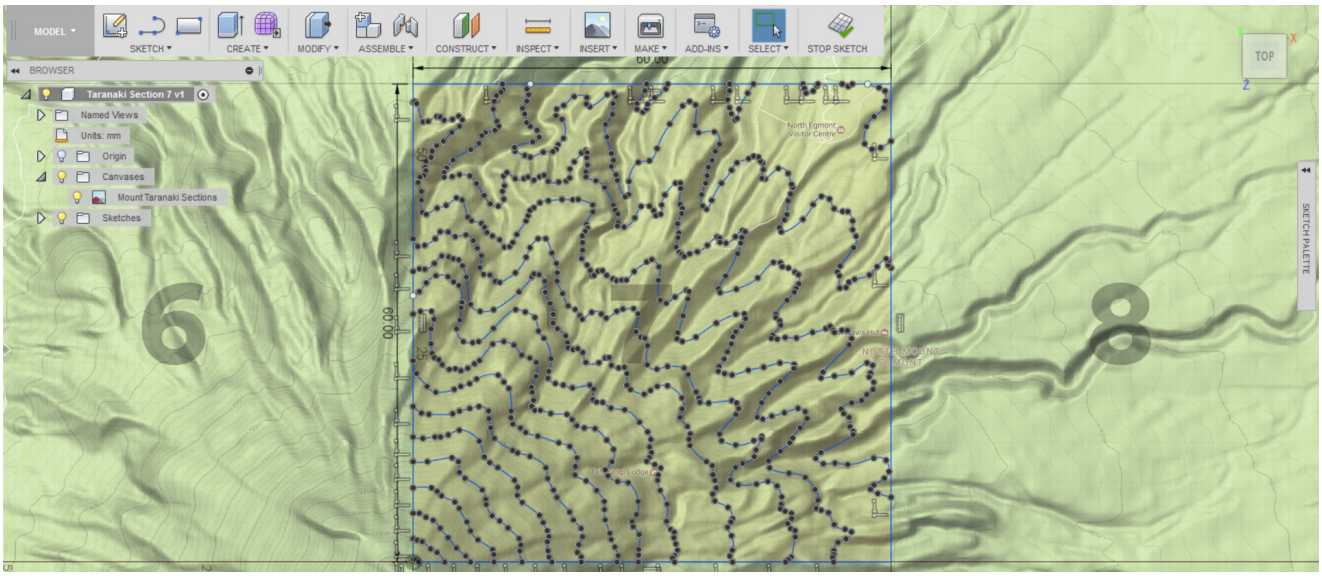
To undo a command press ctrl+z.



d. To draw the curved contours we will be using a tool called the “spline” tool. To activate this click sketch > spline. If you hover over the edge of the rectangle you have just drawn you will notice that it snaps to the line. When starting and finishing contours that meet this edge, make sure the start/ end points snap to the edge of the rectangle.

e. Click on a point along the edge of your rectangle where a contour intersects. You have now started drawing a spline. To continue your spline click more points on your contour line. The points you click should be at the start and end point of curves. Take a few moments to experiment with the tool but remember, the less points the better. As you progress through your line, the spline may move slightly off track from your contour but we can fix this after the spline is completed. When you finish your spline click the tick to complete it and you will see a series of “handles” appear on each curve. You can drag these handles to amend the arc of each curve. If your contours contain a lot of curves you might notice your computer running quite slow. If it does this you can finish your spline mid-way by clicking the tick. Then press esc to deactivate the tool, click on an area that is not your spline, then press esc again. Then start drawing another spline that connects to your first one. You should repeat the esc-click-esc method when you finish all splines.

Repeat the process for the rest of your contours. Your sketch should look similar to the below. Now click stop sketch.



6 Extrusion Calculations

We have now created a series of surfaces ready to extrude. The next step is to work out how far we need to extrude our surfaces. Go through the below calculations.

a. What is the thickness of each contour surface of your 3D model? Work out the answer by dividing the difference in elevation between your contours by the scale of your model. Convert the answer to mm and write it in the below box. In our example the difference in elevation between our contours is 100m and the scale is 1:50,000. Therefore the contour thickness is 100/50000=0.002m = 2mm.

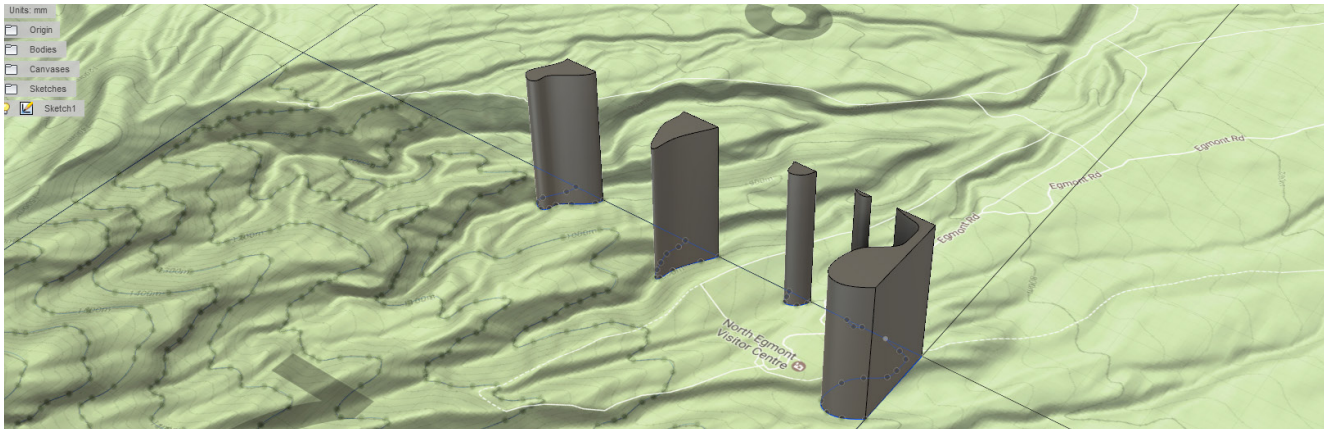
b. Write down the lowest contour elevation on your allocated section. You may have to zoom in and look at another contour map section to see the contour label for your lowest contour.

c. What is the difference in elevation between the base elevation (worked out in section 2a) and the lowest contour elevation on your allocated section?

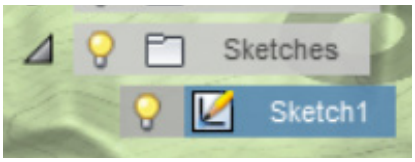
d. What is the distance you need to extrude your first contour (the lowest contour on your allocated section)? The answer should be the value stated in question 6c divided by the scale of your model. In our example our lowest contour is 900m and the difference in elevation between the base elevation (300m) and lowest contour elevation is 600m therefore we need to extrude this contour by 12mm (600/50000=0.012m = 12mm).

7 Extrude your Model

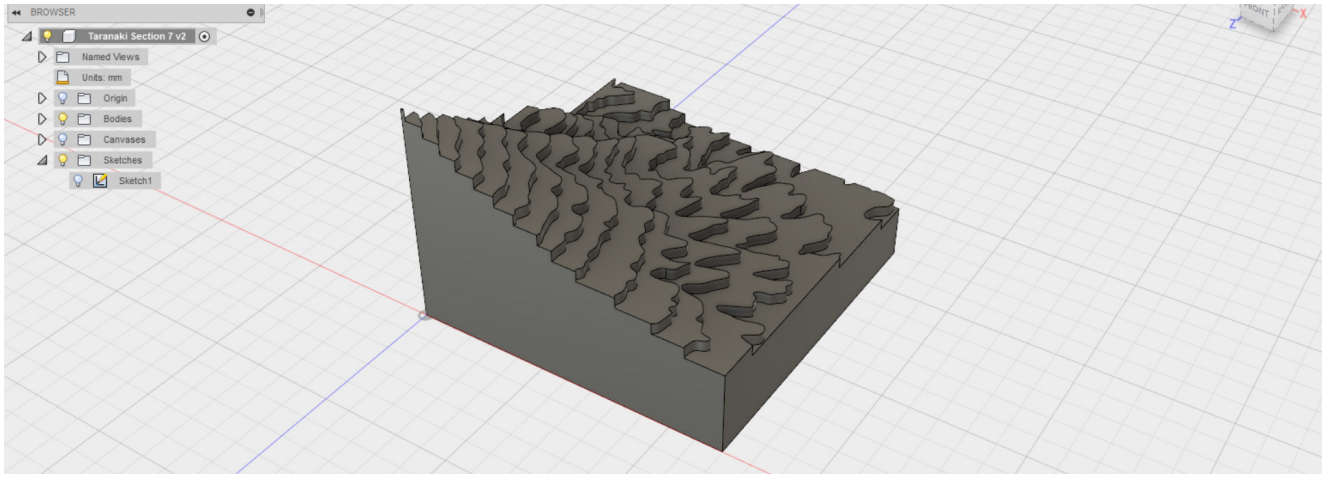
a. Click create > extrude. Click on the surface of your lowest contour. When you have selected the surface you will see a measurement box pop up. Enter the extrusion distance - this will be the same as your answer to question 6d, then press enter. In our example below, our lowest contour runs in and out of our square section. Therefore we had to make several extrusions.



b. You may notice that your sketch has now disappeared. To make it reappear click the arrow next to sketches on the left side of your screen. The light bulb will be "off" and to turn the layer back on, all you have to do is click on the bulb.



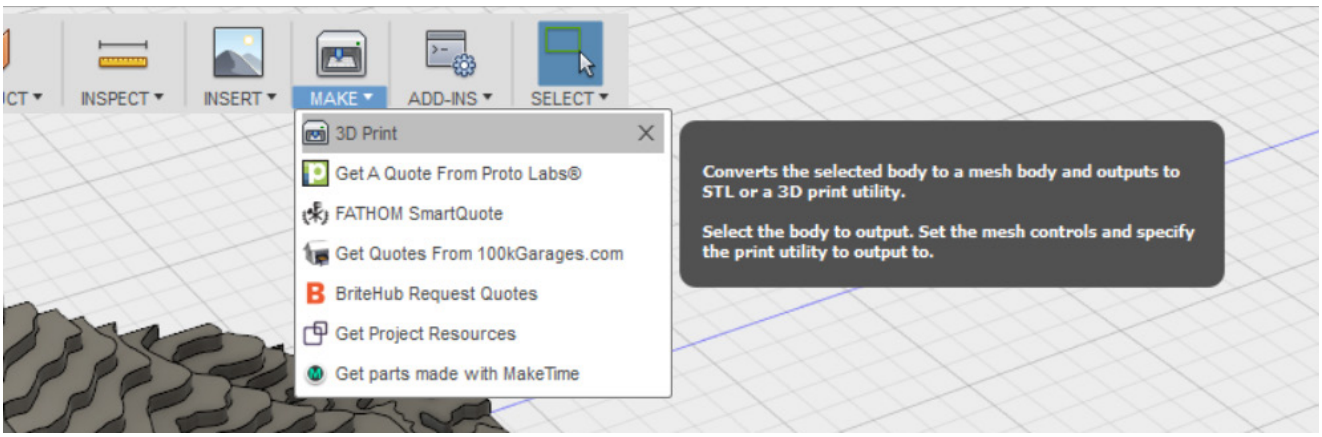
c. Repeat step a for the rest of your contours. You can calculate the distance you should extrude each contour (as you did in step 6d). A shortcut is to simply move to the next contour up from the one you have just extruded and extrude it by the same distance as your first extrusion + the thickness of your contours (your answer to 6a). In our example we extruded our first contour surface by 12mm. The next contour up should be extruded by 14mm as our contour thickness is 2mm. Once you have completed all extrusions, click the light bulb next the "sketch" layer and also the "canvasses" light bulb to turn them off. Your final model should look something like the below.



8 Export your 3D Model

The final step is to export your model into a 3D printable format known as an STL. First of all save your work by clicking the “save” icon at the top. Make sure your section number is in the file name.

a. Click make > 3D print.



b. In the 3D print menu, deselect send to 3D print utility. Select your model by clicking on it then click ok to export your model.

c. Save the STL to your school’s server. Name it the section number that was allocated to you.

Well done - you have completed the student workbook and your teacher will now demonstrate the 3D printing process!

If you have completed the workbook before other students, start working through this YouTube tutorial where you will design a 3D printable lampshade - http://bit.ly/2pj6SL0.