GENERAL 3D PRINTING INFORMATION

Costs for 3D printing:

$10 per cubic inch of Model Material

$10 per cubic inch of Support Material

$10 per bed (multiple small pieces can be printed on the same bed)

3D printer operators will advise on projected costs when a fully prepared .STL file is received. No other file format is acceptable. Download third party plug-ins and add-ons if required to export as .STL.

Daniel Brown (Daniel.j.brown@adelaide.edu.au, phone available via reception) will be here for the last few weeks of each semester based in room 513 opposite the ADSA green door for free consulting services on preparing and getting models 3d printed.

There are outside companies as well eg

3D Prototypes and Models	Tea Tree Gully	danieljbrown88@gmail.com	0415 246 775
Adelaide 3D Printing Services	Happy Valley	geoff@3dprintsa.com.au	0415 891 116
Adelaide 3D Printing	Moana	info@adelaide3dprinting.com.au	0404 418 886
Castech 3D	Wingfield,	jeff@castech.net,	8349 7299

The printer we use is a Fortus 250 with a maximum print size of **25.4*25.4*30.5** (L*W*H) centimetres. As per the laser cut all payments are in advance and there are no refunds if the model is bad, please ensure your model has been correctly prepared first.

SPECIFIC 3D PRINTING INFORMATION

3D printing is the process of first digitally slicing up a 3D model into layers a fraction of a millimetre thick, then using a computer-numerically-controlled machine to mechanically draw these layers down one by one onto a 'bed' using model material, for architecture purposes this will typically be molten plastic or a powder. This process is **SLOW**. For every detail, every window frame, stair and pillar, the printer must move to the location, print the object, and then move to the next. Once the entire layer of the model is drawn, the process repeats itself, up by the next fraction of a millimetre. For many models, there can be well over 1,000 individual layers printed. In addition to this, any 'floating' structure require underlying support to be built which are dissolved away after printing. It is comparable to imagine 2D printing 1000 pieces of paper and having to glue each one together after each layer is printed.

This concept is critical to understand and appreciate and it leads into many of the issues that must be addressed to 3D print your model.

The speed of 3D printing however is overshadowed by the demand for it. With heavy demand and a slow operating speed, ensuring your model is correctly prepared as soon as possible will give you the best possible chance at getting your print finished on time. This guide will highlight a variety of things you can do to get your model printed on time, on budget and with minimal stress.

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The first aspect to explain is the scale. 3D printers are not large and the biggest commercially available printers (that are actually accessible to students) are usually restricted to around 290mm in any direction. Printers are not larger than this due to significant cooling and stability issues on large parts. When you have a model required to be, for example, 1:200 and it is larger than the print volume, you must slice it up into parts. This is a fairly basic process and 3D prints can be glued together easily. More importantly though, larger parts take significantly longer to print and therefore cost more. Since these machines operate in 3D, a 1:100 part is twice as large as 1:200 yet this translates into a 2*(x-dimension) * 2*(y-dimension) * 2*(z-dimension) = 8 times larger. There is a direct correlation between time and cost to the objects size therefore a 1:100 can cost up 5x as much and take up to 5x as long as 1:200!

When printing is in demand and deadlines approach, this aspect of 3D printing must be heavily considered. If you absolutely must print a large-scale model it is imperative that you seek to have your model prepared for printing as early as possible. Conversely if the prices and timelines of 3D printing are unsuitable for your needs and you are able to scale your model down, it can save you a lot of time and money.

Other aspects can alter the cost and deadline slightly but are typically more of a function of the quality and strength of the part, rather than the cost and timeframe. You can request a part printed at a lower ‘resolution’ and ‘infil’. The printer allows you to set the height of each layer it puts down, and how solid it builds the part. If you are building an external geometry part (like many files generated from Rhino) you can request a low infil % which will make the interiors mostly hollow. This can dramatically reduce the costs of the part depending on how much of the part is enclosed. Parts with a low surface area to volume ratio (such as a sphere) can have the costs and time less cut down anywhere up to 40% by having a more hollow model. However complex thin-walled structures (like a façade) have a very high surface area and comparatively very low volume to hollow out. In cases like these, you will not want to reduce the infil.

It is critical that 3D prints have a sufficient wall thickness to print. Typically, any less than 1.2mm is dangerously thin and poses a risk of breaking during printing or more likely to break when the part is post-processed in the dissolving bath. When shrinking a model down to size you must consider the thinnest parts of your model and if reduced to 1:200, how thick will they be in the printed model? Thickening of all walls in any 3d printed part is usually required. 3D printers cannot print ‘planes’ or walls with 0 thickness, they will simply fail to print anything, it must have a defined thickness.

By requesting a lower resolution, the printer will make objects coarser and have more obvious layers however it can dramatically reduce the time required of the print. This may only marginally reduce the costs but if time becomes critical, this aspect, when combined with a low infil, can cut down the printing time of a part anywhere up to 3x of the default settings duration of a similar print. If you are

ever quoted with a turnaround time that is beyond your deadline, request a lower resolution, it may be the difference you need.

3D printing has a minimum feature size defined by the machines accuracy and the nozzle. The printer at the university, the Fortus 250, has a minimum feature size reported at 0.3mm. This means that any feature, when shrunk down that is below 0.3mm, will simply not print, the machine will not even attempt it. This is rarely ever an issue however if your model has features like a door handle, they may not print when shrunk down.

To prepare a file for 3D printing, it must be exported as a .STL file. Most 3D modelling programs can do this however some may require a plug-in. Different programs have different success rates in exporting complex structures into a 3D printable format. More advanced and industry standard programs have a high success rate while some more complex shapes on more general programs may require re-work on aspects such as closing voids and thickening of walls.

There are about 38 ways to cause a 3D print to fail while only around 6 for a laser cut. A few common ones are;

1) The model is too thin such that the structure breaks when the supports are dissolved in the agitating bath.
2) The model contains many 'voids' and walls which are not properly connected resulting in walls falling apart after printing or failing to print at all.
3) When scaled down to printing size, thin sections such as window frames become too small to actually print (below 0.3mm)

Complex geometry made in Rhino is common and a good document to refer to for Rhino specifically can be found at

http://isites.harvard.edu/fs/docs/icb.topic907832.files/preparing-3D-print-files.pdf

3D print files made in any program can be automatically 'repaired' using Netfabb's cloud-based service online. It is advised that any .STL file generated for 3D printing to be uploaded and downloaded from the website which will attempt to iron out most issues automatically. It has a high success rate however no guarantee is made on it since it is automatic. The manual version which the university owns can identify and solve problems the cloud service doesn't.

Sketchup is strongly not recommended for 3D printing. If you have a project where you intend to 3D print a model you are advised to start the modelling process using another program. Sketchup files can be repaired for 3D printing but rework is often very significant to the point of being able to create it from scratch again, quicker.

The university charges $10 per cubic inch of material used, $10 per cubic inch of support material used (which is dissolved away) and $10 for each board (they are not re-usable). These costs are directly calculated using printing software to give you an accurate quote once a fully-prepared .STL file is given to the 3D printer operators at the university. Since the charges are based on material used, choosing a low infil can usually save time and money however lower resolution will only save time. Since each and every 3D print is unique, and often so unique that different brand printers would print them in different ways, estimating cost is impossible unless a prepared file is ready. For

a rough guide though, a house that fits within an envelope of 6x6x6cm will cost $50, 9x9x9cm^3 will cost $100 and 12x12x12cm^3 will cost $170. Any 3D printed part which fits in those dimensions will cost an amount relative to the volume it takes up compared to the overall cube volume. More exotic shapes and long, flat pieces must be inspected visually and calculated to come up with a ball-park figure quote, however.

To deal with certain geometries, it may be quicker to use combinations of laser cuts and 3D prints. 3D printing is fantastic for complex shapes however long, flat sections such as boardwalks or roofs can often be handled more efficiently by laser cutters. This is especially true on larger models. 3D printing of high surface area parts can have a significantly longer print time and higher cost than a laser cut flat wall, it is advised to split up models with large flat sections into laser cut and 3D printed components to save you time and money.

Finally, there are multiple options to get your models 3D printed. Whilst the university owns a very accurate, precise and reliable printer in the Fortus 250, printing demand routinely sees the printer booked-solid well before due dates of large projects. There are a number of external businesses and community workshops to handle printing for you which offer a range of different printing technologies. You are advised to keep these options in mind as they can offer a range of qualities, timeframe, colours and costs to suit all sorts of applications. Much like the universities printer though they have a tendency to get booked out as well, so remember to approach them early if you feel you need their services.

3D printing can be daunting and while the technology seems to be prohibitive in many aspects, correctly working with it can save you a lot of time, money and importantly, stress. They follow the programming law of ‘Garbage in, garbage out’ and so it is critical to ensure a properly prepared and scaled model goes ‘in’ to the printer, so your model exactly as you want it, comes ‘out’ of it.