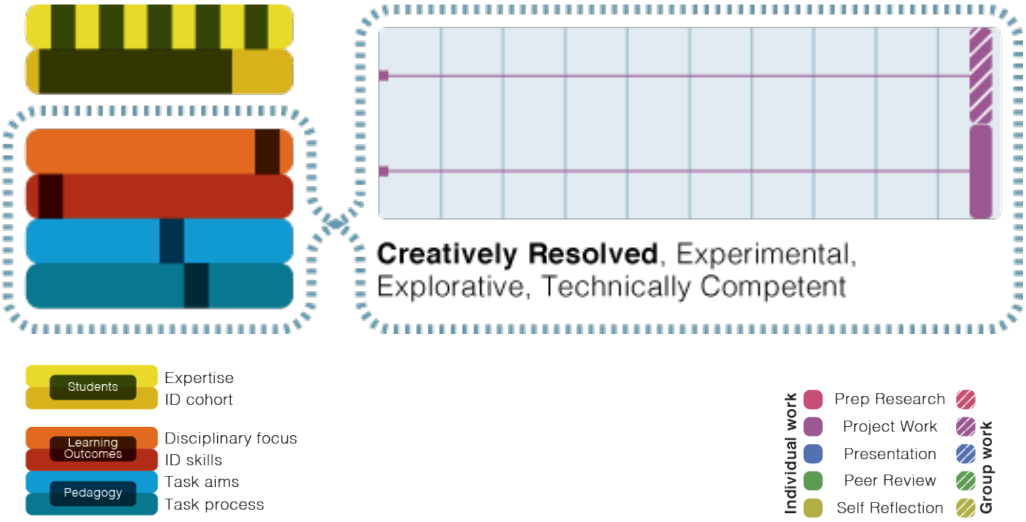
MM20

University of Tasmania
Digital 3D Fabrication

multiplemeasures.org.au



SUMMARY FOR BENCHMARKING

How well is interdisciplinary learning supported by the assessment design?

This study aims at expanding a student's skill set, through a strongly directed technically focused set of exercises, followed by a student-orientated project. The key ID contribution is from a range of perspectives delivered by staff acting as 'consultants' to assist innovative development of students' individual projects.

How well does the assessment design fit the ID cohort?

Does it fit the level of *student expertise*?

Strongly directed unit/subject/course is suitable for early year levels, but some level of open endedness for outcomes allows experimentation for more confident / mature students. The study is offered for multiple year levels and may also be supported by a relatively small cohort size, allowing more personal support by staff. The intensive mode of delivery may also bring a production focus to the project work that reduces difference across the cohort.

Does it respond to the *range and style of cohort learning expectations*?

The unit/course/subject supports variety of learning interests and cultures in the content explored, however bias towards art learning culture in the assumed application of the knowledge that students will gain through the unit.

How well does the assessment design align to intended ID learning outcomes?

Do the *tasks and criteria* sufficiently support development of students' *disciplinary practices* ?

Extends/deepens particular and technical skills and knowledge that students may then connect to their 'home discipline' focus or interests.

Do the *tasks and criteria* sufficiently support development of students' *interdisciplinary skills* ?

No emphasis on broad ID skills such as collaboration etc. in the development of the unit.

Do the student and staff roles influencing the *direction / aims* of the tasks support the ID learning outcomes?

Student directed outcomes are encouraged within a broad framework set out by staff. The key focus is on technical development however, with a view to the future application of these new skills.

Do the student and staff roles influencing the *process / development* of the tasks support ID learning outcomes?

Structured learning process sets out the first set of strongly directed projects followed by the open-ended application of these skills within a student directed project.

This summary draws on interview data collected through the **Multiple Measures** project, as well as materials produced by academics developing this unit/course/subject.
The **Multiple Measures** project was funded by the Australian Government Office for Learning and Teaching

UNIT/SUBJECT/COURSE OUTLINE + OUTCOMES

This three-week intensive and practical unit will explore contemporary techniques for both scanning and modeling 3D forms, as well as staged skill acquisition from concept sketch to 3D model, with subsequent refinement to produce machine ready files.

Students will be exposed to a range of software and processes, but the focus of this unit is not on the training in using a specific software package, but in the application of software to these fabrications devices. Exercises will explore strategies from creating and constructing forms and the preflight checking of files for a variety of print, routing and cutting processes.

Learning Outcomes:

- Utilise software at an intermediate level for fabrication processes, including identification and resolution of fabrication problems
- Demonstrate knowledge of the technology and terminology
- Prepare files for a variety of commercial fabrication processes
- Understand the concept of design workflow utilising technology

UNIT/SUBJECT/COURSE ACTIVITIES & ASSESSMENT TASKS

Assessment task 1: Exercises (50%) A series of 5 exercises to be undertaken both inside and outside class sessions: Jigger-saw, Volume, Adapt-or-die, Slowgram selfie and Flayed mesh. Each exercise has a deadline for production and machining. Students are required to submit a reflection statement describing the design intention, and the outcome of each exercise (500 words), journal sketches, CAD drawings and screenshots of CAM simulations as well as the physical artefacts.

Assessment task 2: Self Directed (50%) Self-directed design and fabrication project. Submission should be a maquette or scale model, but must result in a physical outcome that uses one of the digital fabrication processes explored in the unit. Submissions should also include: a physical outcome, CAD files and a reflection statement (300words) stating the intention and reflecting upon the process and outcomes.

ASSESSMENT CRITERIA / MARKING

- Expression and form
- Exploration and experimentation
- Technique
- Completeness

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Tasmanian College of the Arts

Faculty of Arts

FSF202
DIGITAL 3D FABRICATION

Winter, 2015

Unit Outline

CRICOS Provider Code: 00586B

This detailed information provides background to the MM summary.
The content was originally produced for the delivery of this unit/subject/course.
Some content not directly relevant to the Multiple Measures project has been edited/removed.

Contents

WHAT IS THE UNIT ABOUT?

Unit description*

The 21st century is presenting a revolution in making that is characterised by a departure from the heavy infrastructure of mass production to the bespoke digital design and manufacture of objects. CNC Routers, 3D printers, Laser cutters are revolutionizing this bespoke production. Often this technology is hyped which can obscure the practicalities of utilising these technologies.

This practical unit will explore contemporary techniques for both scanning and modeling 3D forms, as well as staged skill acquisition from concept sketch to 3D model, with subsequent refinement to produce machine ready files.

You will be exposed to a range of software and processes, but the focus of this unit is not on training in using a specific software package, but in the application of software to these fabrication devices.

Exercises will explore strategies for creating and constructing forms and the preflight checking of files for a variety of print, routing and cutting processes.

You will undertake a self-initiated project taking a concept from initial sketch to fabrication of a prototype (not necessarily at full scale).

Intended Learning Outcomes*

On completion of this unit, you will be able to:

1. Utilise software at an intermediate level for fabrication processes, including identification and resolution of fabrication problems.
2. Demonstrate knowledge of the technology and terminology.
3. Prepare files for a variety of commercial fabrication processes.
4. Understand the concept of design workflow utilising technology.

Graduate Quality Statement

Successful completion of this unit supports your development of course learning outcomes, which describe what a graduate of a course knows, understands and is able to do. Course learning outcomes are available from the Course Coordinator. Course learning outcomes are developed with reference to national discipline standards, Australian Qualifications Framework (AQF), any professional accreditation requirements and the University of Tasmania's Graduate Quality Statement.

> The University of Tasmania experience unlocks the potential of individuals. Our graduates are equipped and inspired to shape and

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respond to the opportunities and challenges of the future as accomplished communicators, highly regarded professionals and culturally competent citizens in local, national, and global society. University of Tasmania graduates acquire subject and multidisciplinary knowledge and skills and develop creative and critical literacies and skills of inquiry. Our graduates recognise and critically evaluate issues of social responsibility, ethical conduct and sustainability. Through respect for diversity and by working in individual and collaborative ways, our graduates reflect the values of the University of Tasmania.

Alterations to the unit as a result of student feedback*

This is the second time this unit has been run, projects have been refined and tweaked as a result of student feedback.

Prior knowledge &/or skills

No previous CAD/CAM knowledge is required, however students are expected to have Intermediate level computer skills, including:

- Understanding of file management on Windows and Macintosh computers.
- Understanding of Windows and Macintosh graphic user interfaces
- Experience with software for digital imaging or drawing (doesn't particularly matter what it is, could be Photoshop, Illustrator, Flash, AutoCAD, Rhino, Canvas, 3D Studio Max, Sketchup, Blender, etc)
- Intermediate spatial thinking skills. This is the ability to visualise in the minds eye how shapes will fit together.
- High school level geometry (e.g. http://www.mathsisfun.com/geometry/index.html or http://www.mathopenref.com/) including:
    - Understanding of measurement units, and concepts of tolerance/accuracy in measurement of length and angles. (To review: http://www.mathsisfun.com/measure/index.html)
    - Understanding of the relationships between length, area and volume. (To review: http://www.mathsisfun.com/measure/index.html)
    - 2-D and 3-D Cartesian coordinate systems (grids) (To review: http://www.mathsisfun.com/data/cartesian-coordinates.html)
    - Vectors in 2-D and 3-D space. (To review: http://www.mathsisfun.com/algebra/vectors.html)

- Transformations in a Cartesian coordinate system, such as rotation, translation, reflection, scale. (To review: http://www.mathsisfun.com/geometry/transformations.html)

- Some ideas about what you want to do with this technology!

Glossary

Drawing - An engineering document or digital data file(s) that discloses (directly or by reference), by means of graphic or textual presentations, or a combination of both, the physical and functional requirements of an item.

Model – A graphic representation

Point - Graphic element representing a position in space, also known as a **vertex**.

Polyline – A series of connected lines, arcs or curves that behave as one entity. A **closed** polyline has its endpoints connected.

Spline - A mathematical tool for describing curves or surfaces.

Polygon - An object composed of three or more connected straight lines in a closed figure, such as a triangle or rectangle.

Surface – A 3D model that does not enclose a volume, such as a plane

Mesh – A 3D model as a finite set of vertices connected together to the faces or facets

NURBS (Non Uniform Rational B Splines) – A mathematical tool for describing surfaces using B-Splines. Often used for Organic modelling.

Recommended File Formats and ways to use

DXF – used to exchange 2D drawings between programs. Be aware that there are many different versions of DXF files, and compatibility is not assured between different version and line encoding styles. So needs to be used with care and attention.

STEP – use in preference to DXF but not as widely supported

STL – Used to exchange 3D models. This is a robust "Mesh" only format widely used for 3D printing and machining.

SVG – Scalable Vector Graphics format, an opensource format widely supported by Adobe and OpenSource / Browser based software.

PNG – Used for image data. Lossless, use in preference to JPEG.

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HOW WILL I BE ASSESSED?*

Assessment schedule*

Assessment task	Date due	Percent weighting	Links to Intended Learning Outcomes
Assessment Task 1: Exercises	Progressive (see below)	50%	All
Assessment Task 2: Self Directed	6th July, 5pm	50%	All

Assessment details*

Assessment task 1

Task description	A series of 5 exercises to be undertaken both inside and outside class sessions. Each exercise has a deadline for production and machining (see Unit schedule). These tasks will be assessed as a group at the end of the unit. Your submission should include a reflection statement describing the design intention and the outcome of each exercise (500 words), journal sketches, CAD drawings and screenshots of CAM simulations as well as the physical artefacts. It is important to keep in mind with these exercises that failure is not catastrophe, mistakes and problems are there to learn from so that you can forsee them in the future. A successful physical outcome for all of these exercises is not our sole objective. 1. *Jigger-saw*– 2D CNC cutting and tool path generation, using 3mm MDF and a 6.4 mm bit. Create 5 interlocking shapes from a sheet of 3 mm MDF 30 x 40 cm, that when cut and locked together form a square. Shapes should snap together snuggly, and form the largest square you can. 2. *Volume* - Laser Cutting using 4.5 mm thick white acrylic. Design, produce and assemble the largest volume containing form you can imagine using flat laser cut parts that fit inside a 20 x 20 cm square. The final form needs to have structural integrity, i.e. the model can be picked up and moved without falling apart. 3. *Adapt-or-die* - 3D Printing using PLA and/or ABS plastics.

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	Design a 3D adaptor/connector that joins two physical objects together. Maximal dimension in any direction is 4cm. Some examples might be a holder to strap your phone to your forehead; attach a pen to your skateboard; a remote control with a bottle opener….. 4. *Slowgram Selfie* - Milling and tool path generation, develop a height map image to be milled. The image should be a self-portrait and be 4 x 4 cm square to be milled to a depth of up to 2.5 cm. This is not as simple as taking a photo and treating it as a depth map – you will need to reconstruct the image to use tone to represent milling depth. 5. *Flayed Mesh* – Take or make a 3D mesh model and unfold to print and then cut or laser cut as a A4 to A2 paper craft model – fold and glue to assemble. To be practical your model should have no more than 20 faces or polygons.
Assessment criteria	• Expression (Is it an interesting idea or a novel approach? Is the final form of the idea resolved?) • Technique & Form (This is about the making - technically how well have you used the various technologies to produce the finished work. Is the final form well crafted?). • Knowledge (have you demonstrated an understanding of the technological processes and the materials you are using). • Completeness (has everything required been submitted).
Links to unit's intended learning outcomes	All
Date due	Each exercise has a deadline for file submission for machining noted in the unit schedule. Failure to meet these deadlines will mean that your object cannot be produced and the exercise completed. Please note that while design is an iterative process, and you may wish to correct/refine your design time/material constraints may make it difficult to machine projects multiple times. An incomplete outcome for an exercises is not necessarily a disaster, particularly if you reflect on how you would correct/refine the design. **The summary of these exercises will be due at the end of the unit 5:00 pm Wednesday the 6th.**

Assessment task 2

Task description	Self-directed design and fabrication project. Submission should be a maquette or scale model, but must result in a physical outcome that uses one of the digital fabrication processes

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	explored in the unit. There is a maximum of up to 2 hours machine usage (printing / cutting / routing) to produce your parts. Submission should include: • Physical outcome (maquette) • CAD files • Reflection statement (300 words) stating the intention and reflecting upon the process and outcomes Journal documenting initial ideas, sketches, contextual and technical research, stages of production.
Assessment criteria	• Expression & Form (Is it an interesting idea or a novel approach? Is the final form of the idea resolved and satisfying?) • Exploration & Experimentation (How widely have you looked for a design solution? Is your approach clever, have tried different approaches? Have you compromised or persevered?) • Technique (How well have you used fabrication technologies to produce the finished work). • Completeness (has everything required been submitted)
Links to unit's intended learning outcomes	All
Date due	**5:00 pm Wednesday the 6th.**

How your final result is determined*

See the 2015 TCotA Student Induction Information Handbook, Hunter Street, for further details of the art program policy on review of assessment processes.

Submission of assignments*

Working digital files for machining, should be submitted via MyLO dropbox. Reflection statements / journals and final digital files should also be submitted via DropBox. Final submission of work will include the physical objects and should be submitted in the work area outside the computer lab.

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Resources

Equipment, materials, software, accounts

- Graph Paper / Journal
- Drawing implements
- Steel ruler
- Vernier Calliper
- Other drawing / making implements such as a triangle, protractor, knife and glue stick would be useful.
- 2 x USB thumb drive
- Autodesk student account go to http://www.autodesk.com/education/free-software/all and click a GET SOFTWARE button, then select CREATE ACCOUNT.
- Materials for your self directed project.

This focus of this unit is not on training and certification in using software package/s, but on utilising the appropriate software to the physical processes of engraving / cutting / milling / printing using fabrication technology. E.G. an understanding of appropriate file preparation and format is given more weight than virtuosity with a particular package. You don't need to understand every technique for using a chisel before you use one, but you do need to know the basics of how to use it safely.

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Software that might be used with these processes include 3D Modelling tools such as Maya, 3D Studio Mac, Imaging tools like Adobe Photoshop, Drawing tools like Adobe Illustrator, or potentially even Microsoft Word for engraving text.

CAD (computer aided design) tools are different to the above applications in their precision, they are not “creative” tools as such but engineering tools – use CAD when you know what you want to do. There are many, many CAD programs (around 60 are compared on Wikipedia). CAD software should be distinguished from CAM (Computer Aided Manufacture) software, which is the software used to generate the instructions that control the machines.

Most teaching / demonstration will occur in the Electronic Media computer lab. This is a Macintosh lab, for Windows users the main difference is the use of the Control (Ctrl) and Command (Apple) keys, see here http://www.macinstruct.com/node/433 for how to swap them for more windows like behaviour. You may use your own computer if you wish, but you will need to download and install the required software and versions. It is essential to have a mouse and screen resolution of at least 1440x900.

Software (probably not exhaustive) that will be used / demonstrated in this unit, unless otherwise stated, is chosen to be dual platform (windows and mac), readily available (not too expensive or specialist), functional and easy to learn.

- Adobe Illustrator (http://www.adobe.com - 30 day trial through Creative Cloud) is a drawing / tracing program.
- Rhinoceros “Rhino” (http://www.rhino3d.com/ 45 trial available) is a NURBS based CAD program. It s primarily meant to be “3D” but also does 2D drawing well. Rhino is large and complex and has many add-ons. It will be the main tool used for this unit. See MyLO for additional Rhino learning resources.
- 123D Make, 123D Catch, 123D CNC Utility, Autodesk 3D Print Utility – are all free “cloud” applications from Autodesk, but require an Autodesk user ID.
- Gcode visualiser and analyser for 3D printing http://gcode.ws
- OpenSCAM (http://openscam.com free) – software for simulating a 3 axis CNC machine.

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Unit schedule

Week	Date beginning	Topic/ Module/ Focus Area	Activities	Resources/ Readings/ Further Information
1	Tues 16th June	• Spatial thinking – the design process from sketch to object • The New Makings.	• The Rhino way and CAD thinking • Points, lines, curves and splines • Close enough is not good enough - the importance of being snappy	Non assessed in-class exercises Introduce 1st assessment exercise *Jigger-Saw*

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		• Workplace Health and Safety		
2	Wed 17th June	• The CNC process, from design to machine	• File preparation for CNC cutting. • Setting up a tool and creating a tool path • Visualising and checking your toolpath • Pre flight checks for CNC cutting	Non assessed in-class exercises Work on first assessment exercise
	Thurs 18th	Exercise 1, drawing flight checked for CNC and submitted to drop box by noon for cutting		
3	Fri 19th June	• Flat pack thinking • The laser cutting process	• 2D drawing to 3D visualisation – does your design make sense? • Laser cutting file preparation and pre flight check.	Non assessed in-class exercises Introduce 2nd assessment exercise *Volume*
	Mon 23rd June	Exercise 2, drawing flight checked for laser cutter and submitted to the drop box by noon for cutting		
4	Tues 23rd June	• Enter the third dimension • What you see, is not what is inside. • 3D printing	• Exercise 2 review • NURBS, Surfaces and Meshes • Standard methods of constructing objects • Manipulating and combining objects	Non assessed in-class exercises Introduce 3rd Assessment exercise *Erector Set*
5	Wed 24th June	• 3D Scanning and Reverse engineering	• File preparation for 3D printing • Work in progress self-directed.	Introduce self-directed project
	Thurs 25th June	Exercise 3, model/parts flight checked for 3D printer and submitted to the drop box by noon for printing (won't be ready until Tues the 30th of June).		
6	Fri 26th June	• Milling and Engraving	• Work in progress self-directed.	Introduce 4th Assessment exercise *Slowgram Selfie*
	Monday 29th June	Exercise 4, image and Rhino file submitted to the drop box by noon for milling.		
7	Tues 30th June	• From 3D to surface, unfolding	• Exercise 3 and 4 review • Self Directed project machine /	Introduce 5th Assessment

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		and other extensions to Rhino • Mould Making	equipment scheduling.	exercise *Flayed Mesh*
8	Wed 1st July	• Surveying other DIY possibilities , physical computing, electronics	• Work in progress self-directed.	
	Thurs 2nd July	Exercise 5 DXF and PDF & Rhino file submitted by 12 noon for cutting.		
9	Fri 3rd July	• What have we learned ?	• Exercise 5 review • Self Directed project critique	

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Assessment Rubric Task 1 Exercises

Criteria	HD	DD	CR	PP	NN
Expression	To develop the work you:	To develop the work you:	To develop the work you:	To develop the work you:	You:
This is about the idea for your work, how you have responded to the brief, and how you have developed and interpreted that idea. **Expression is how you use technique and formal knowledge to communicate your intent.** **Is this a clever idea or interpretation of that idea? Is it innovative? Is it aesthetically pleasing?**	• Had an innovative idea • Considered and found an insightful approach to communicating it. • Went through a thorough process of development and refinement • Powerfully communicated your intent through the work.	• Had an interesting idea • Considered and found a solid approach to communicating it. • Went through some development and refinement • Effectively communicated your intent through the work.	• Had a solid idea • Considered your approach to communicating it • Attempted to develop and refine your work • Communicated your idea through your work.	• Had an idea • Communicated aspects of your idea through your work	• Had an idea
Knowledge	Your work could be successfully produced because you:		Your work could be produced with some problems because you:		Your work could not be produced because:
A demonstrated understanding of the technological processes. E.G. file are in the appropriate format, drawings have been flight checked	• Used the appropriate file formats • Files were correctly flight checked • Drawings / Models met the specified sizes and requirements • Could be successfully machined / printed using the specified material/s		• Mostly used the appropriate file formats • Files were flight checked with minor problems remaining • Drawings / Models mostly met the specified sizes and requirements. • Some minor problems with machining / printing using the specified materials		• File formats were not appropriate, e.g. you used an image format where you should have used a vector • Files were either not flight checked or had significant problems remaining. • Drawings / Models didn't meet the specified sizes requirements. • Not practical to machine / print using the specified materials.
Technique & Form	To construct the work you:	To construct the work you:	To construct the work you:	To develop the work you:	You:

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The level of craft and skill displayed in making the work.	• Used the required software to produce a sophisticated and surprising outcome • Produces a well finished and resolved physical outcome	• Used the required software to produce a sophisticated outcome • Produced a well finished physical outcome	• Used the required software to produce a substantial outcome • Produced a physical outcome with some finish	• Used the required software • Produced a physical outcome	• Made some work
Completeness	Your submission:			Your submission:	Your submission:
Have you submitted all the required elements	• Had all the required elements			• Missed a minor component	• Was missing more than one component or an essential component.

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Assessment Rubric Task 2 Self Directed					
Criteria	**HD**	**DD**	**CR**	**PP**	**NN**
Expression	To develop the work you:	To develop the work you:	To develop the work you:	To develop the work you:	You:
This is about the idea for your work, how you have responded to the brief, and how you have developed and interpreted that idea. **Expression is how you use technique and formal knowledge to communicate your intent.** **Is this a clever idea or interpretation of that idea? Is it innovative? Is it aesthetically pleasing?**	• Had an innovative idea • Considered and found an insightful approach to communicating it. • Went through a thorough process of development and refinement as documented in your journal • Powerfully communicated your intent through the work.	• Had an interesting idea • Considered and found a solid approach to communicating it. • Went through some development and refinement as documented in your journal • Effectively communicated your intent through the work.	• Had a solid idea • Considered your approach to communicating it • Attempted to develop and refine your work as documented in your journal • Communicated your idea through your work.	• Had an idea • Communicated aspects of your idea through your work	• Had an idea
Knowledge	Your work could be successfully produced because you:		Your work could be produced with some problems because you:		Your work could not be produced because:
A demonstrated understanding of the technological processes. E.G. file are in the appropriate format, drawings have been flight checked	• Used the appropriate file formats • Files were correctly flight checked • Could be successfully machined / printed using the specified material/s		• Mostly used the appropriate file formats • Files were flight checked with minor problems remaining • Some minor problems with machining / printing using the specified materials		• File formats were not appropriate, e.g. you used an image format where you should have used a vector • Files were either not flight checked or had significant problems remaining. • Not practical to machine / print using the specified materials.
Technique & Form	To construct the work you:	To construct the work you:	To construct the work you:	To develop the work you:	You:

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The level of craft and skill displayed in making the work.	• Used the required software to produce a sophisticated and surprising outcome • Produces a well finished and resolved physical outcome	• Used the required software to produce a sophisticated outcome • Produced a well finished physical outcome	• Used the required software to produce a substantial outcome • Produced a physical outcome with some finish	• Used the required software • Produced a physical outcome	• Made some work
Completeness	Your submission:			Your submission:	Your submission:
Have you submitted all the required elements	• Had all the required elements			• Missed a minor component	• Was missing more than one component or an essential component.