

<b>Academic Year</b>	Any	<b>Semester</b>	2
<b>Course Coordinator</b>	Amir Shakouri / Leong Han Yang		
<b>Course Code</b>	PS5887		
<b>Course Title</b>	Making and Tinkering (Lite II)		
<b>Pre-requisites</b>	Subject to School's Approval		
<b>Mutually exclusive</b>	-		
<b>No of AUs</b>	2 AUs		
<b>Contact Hours</b>	3 hours per week and 6 hours of mechanical workshop		
<b>Proposal Date</b>	12 January 2023		

### Course Aims

The course aims to equip you with basic technological awareness, particularly computer simulation and basic prototyping using 3D printing, and other hands-on skills required for building basic equipment and products related to Science and Technology. Through this course, you will develop creativity as you are encouraged to explore different approaches to a given problem, and resilience when facing the need to acquire new technological skills in a limited time in order to solve a given problem. Finally, you will have the opportunity to share and refine your ideas with other makers and tinkerers in this course.

### Intended Learning Outcomes (ILO)

Upon the successful completion of this course, you (as a student) would be able to:

#### Project (PROJ)

1. solve a given problem by applying the knowledge and skills associated with
  - computer simulation using a software such as COMSOL,
  - 3D printing and
  - basic mechanical works.

#### Computer Simulation (CS) using software such as COMSOL

2. demonstrate understanding of the need, process and advantages of computer modelling of real life designs;
3. manipulate models of physical systems and acquire results from the software;
4. construct simple models of physical systems and perform simple simulation;
5. construct a prototype based on the results of the simulation;

#### 3D Printing (3DP)

6. use a 3D drawing software (including Solid-works) to create 3d objects made up of two or more distinct parts and to create assemblies of well-tolerant 3d components;
7. to operate a 3D printer, do a simple 3D print job and perform basic trouble shooting; and
8. post-process a 3D print job;

#### Mechanical Workshop (MW)

9. do basic mechanical work involving aluminum;

10. demonstrate understanding of the functionalities and basic operational principles of CNC machine and 3D metal printer;
11. perform a simple job on a CNC machine; and
12. perform a simple 3D print job on the 3D metal printer.

### Course Content

#### Computer Simulation (CS) using software such as COMSOL

Basic Theory of Numerical Methods, algorithms and computer simulation of Physical Systems  
Introduction to simulation software (such as COMSOL)  
Manipulation of models and construction of 1 dimensional simple models  
Manipulation of models and construction of simple 2,3 dimensional models  
Presentation of Simulation Results

#### 3D Printing (3DP)

Theory and History of 3D Printing  
3D printing technology (including the use of 3D metal printer)  
Sketching using 3D design software (including using Solid-works)  
Post processing techniques

#### Mechanical Workshop (MW)

Workshop Safety  
Drilling and Bending Aluminum  
Operational principles of CNC machine  
Operational principles of 3D metal printer

### Assessment (includes both continuous and summative assessment)

This is a pass / fail course. There is a checklist of ALL the skills that you need to demonstrate in order to pass the course. The course instructor will check the quality of your works/understanding and approve with their signatures. See Appendix 2 for more details.

Component	Course LO Tested	Related Programme LO or Graduate Attributes	Weighting	Team / Individual	Assessment Rubrics
Continuous Assessment	All	Competence, Creativity, Communications Character	100%	Individual / Pair (See Appendix 2)	See Appendix 2
Total			100%		

To pass the course, the you will need to score

- A. a rating of at least 2 out of 5 for all skills items on Appendix 2, and
- B. a rating of at least 3 out of 5 for all items in the rubrics for the final project and project presentation.

**Formative feedback**

At the end of teaching each topic / skill, you will be given time to complete a given task. After that, the instructor will assess you on their understanding and feedback to the quality of their work. The you will have to make improvements until satisfaction before the instructor will sign on the checklist for the you. (See Appendix 2).

**Learning and Teaching approach**

Approach	How does this approach support you in achieving the learning outcomes?
Master-Apprentice	Develop competence in computer simulation and basic prototyping using 3D printing. The instructor will provide feedback to you on their work each session. This will also help develop perseverance and resilience as you will have to improve continually until the desired quality of work is achieved.
Pair Work (Hands-on)	Develop communication skills while doing collaborative learning. You will also have an opportunity to work as a team and do group presentation.
Project	Develop physical intuition and competence in solving scientific / technological problems. The designing of a solution to an open-ended problem also allow you to be creative.

**Reading and References**

COMSOL - <https://www.comsol.com/>  
 SOLIDWORKS - <http://www.solidworks.com/>

**Course Policies and Student Responsibilities**

*Absence Due to Medical or Other Reasons*

If you are sick and unable to attend your class (particularly the mid-terms), you have to:

1. Send an email to the instructor regarding the absence and request for a replacement class.
2. Submit the original Medical Certificate\* to administrator.
3. Attend the assigned replacement class (*subject to availability*).

\* The medical certificate mentioned above should be issued in Singapore by a medical practitioner registered with the Singapore Medical Association.

**Academic Integrity**

Good academic work depends on honesty and ethical behaviour. The quality of your work as a student relies on adhering to the principles of academic integrity and to the NTU Honour Code, a set of values shared by the whole university community. Truth, Trust and Justice are at the core of NTU's shared values.

As a student, it is important that you recognize your responsibilities in understanding and applying the principles of academic integrity in all the work you do at NTU. Not knowing what is involved in maintaining academic integrity does not excuse academic dishonesty. You need to actively equip yourself with strategies to avoid all forms of academic dishonesty, including plagiarism, academic fraud, collusion and cheating. If you are uncertain of the definitions of any of these terms, you should go to the [academic integrity website](#) for more information. Consult your instructor(s) if you need any clarification about the requirements of academic integrity in the course.

**Course Instructors**

	<b>Name</b>	<b>Office Location</b>	<b>Email Address</b>
COMSOL Instructor	Dr Amir Shakouri	N3.2-B2M-12	amir.Shakouri@ntu.edu.sg
3D Printing Instructor	Mr Leong Han Yang	SPMS-PAP-02-07	HYLEong@ntu.edu.sg
Mechanical Workshop Manager	Mr Abdul Rahman Bin Sulaiman	SPMS-PAP-01-06a	AbdulRahman@ntu.edu.sg

**Planned Weekly Schedule**

<b>Week</b>	<b>Topic</b>	<b>Course LO</b>	<b>Readings/ Activities</b>
1	<b>Introduction</b> Introduction to computer simulation; basic numerical methods and algorithms.	PROJ 1 CS 1	^No prescribed weekly readings.
2	<b>Computation Techniques for 1D systems</b> Comparison of computation techniques using different software for simple physical system (such as heat diffusion equation).	CS1	
3	<b>Computation Techniques for 2/3D systems 1</b> Computation techniques for simple 2D and 3D physical systems I (such as 2D heat diffusion, mechanical systems, fluid flow and electromagnetic fields).	CS1-4	

4	<b>Computation Techniques for 2/3D systems 2</b> Computation techniques for simple 2D and 3D physical systems 2 (such as 2D heat diffusion, mechanical systems, fluid flow and electromagnetic fields).	CS1-4	# start Mechanical Workshop
5	<b>3D drawing and 3D printing I</b> Sketching using 3D design software. Post processing techniques	CS5 3DP 6-8	
6	<b>Mini-project</b> Designing and construction of project.	All LOs	
7	<b>Mini-project Presentation</b> Presentation of mini-project and discussion of course Project	All LOs	
8	<b>3D printing II</b> Complex geometries and designing multi-part 3D projects;	3DP 6	
9	<b>Introduction to Advance Simulation</b> Techniques for multi-physics simulation	CS4-5	
10	<b>Project Discussion and Consultations I</b> Construction of project.	All LOs	
11	<b>Progress Report</b> Presentation of project progress.	All LOs	
12	<b>Project Discussion and Consultations II</b> Construction of project and finalizing design	All LOs	
13	<b>Final Presentation</b> Presentation by the all groups	All LOs	

# start Mechanical Workshop (2 Sessions of 3 hours each)

^ No prescribed weekly readings, as they are dependent on individual projects.

Name: \_\_\_\_\_

Learning Outcome Checklist page 1

		Rating*	Sign / Date
	<b>Computer Simulation using COMSOL [Individual]</b>	1 2 3 4 5	
1.	Basic knowledge about computer modelling and COMSOL. (Quiz)		
2.	Demonstrate understanding of the need, process and advantages of computer modelling of real life designs.		
	Modelling simplification		
	Design parameters iteration		
3.	Demonstrate basic understanding of Finite Element Method (FEM) 1D systems		
	Discretization, Weak Formulation, etc.		
	Applying boundary conditions, boundary and/or domain loads and constraints		
	Post-processing of the results		
	Interpretation of the results		
	Investigating of the solution convergence		
	Verification of the FEM model		
4.	Demonstrate basic understanding of Finite Element Method (FEM) 2D or 3D systems		
	Discretization, Weak Formulation, etc.		
	Applying boundary conditions, boundary and/or domain loads and constraints		
	Post-processing of the results		
	Interpretation of the results		
	Investigating of the solution convergence		
	Verification of the FEM model		
5.	Demonstrate ability in using the FEM model provided to practice the design process i.e. by modifying the design parameters and compare the results		
6.	Output the designs based on simulations to stl format for 3D printing		
7.	Involve two or more areas of Physics in a simulation		
	<b>Mechanical Workshop [Individual]</b>		
1.	Demonstrate understanding and awareness of the safety in a mechanical workshop.		
2.	To be able to prepare a drill, drill a hole in a piece of Aluminium (~3 mm thick) and change the drill bit.		
3.	To be able bend a sheet of Aluminium into L-shape.		
4.	Using (2) and (3), make a simple useful object such as simple book stand or toothbrush holder.		
5.	Demonstrate understanding of the functionalities and basic operational principles of CNC machine and 3D metal printer.		

\* 5 – Done perfectly; 4 – Done a very good job but still have some room for improvement;

3 – Completed the job but some improvements can be made;

2 – Completed the job but some major improvements can be made; 1 – Unsatisfactory;

Name: \_\_\_\_\_

Learning Outcome Checklist page 2

		Rating*	Sign / Date
		1 2 3 4 5	
	<b>3D Printing [Individual]</b>		
1.	Basic overall knowledge about 3D printing and applications (Quiz)		
2.	Able to use a 3D drawing software:		
	to sketch, scale, position basic 2d sketches		
	to sketch, scale, position basic geometrical 3d objects		
	to combine 2 or more geometrical 3d objects into complex objects		
	to create assemblies of well-tolerant 3d components		
3.	Basic understanding of settings/parameters for 3d printing:		
	Layer Height and Resolution		
	Optimizing Orientation and Strength		
	Overhangs and Supports		
	Generation of 3D Print File from STL File		
4.	Post processing		
	Combining separate parts into single piece		
	Surface finishing techniques		
	Paint or colour application		
	Part duplication		
5.	Basic troubleshooting skills		
	Adjustments to increase load strength		
	Adjustments to improve print quality		
	Adjustments to reduce print time		
6.	Proficiency using Solid-works		
	<b>Mini-Project [Pair]**</b>		
	<b>Mini-Project Presentation [Pair]**</b>		
	<b>Final Project [Pair]**</b>		
	<b>Final Project Presentation [Pair]**</b>		

\* 5 – Done perfectly; 4 – Done a very good job but still have some room for improvement;  
 3 – Completed the job but some improvements can be made;  
 2 – Completed the job but some major improvements can be made; 1 – Unsatisfactory;  
 [You will need to get at least a rating of 2 for all items to pass.]

\*\* Refer to Assessment Rubrics in the following page. [You will need to get at least a rating of 3 to 5 for all items for Project and Project presentation to pass.]

**Assessment Rubrics for Project Presentation**

	<b>Exceptional (5)</b>	<b>Effective (4)</b>	<b>Acceptable (3)</b>	<b>Developing (2)</b>	<b>Unsatisfactory (1)</b>
<b>Content</b>	Provides more than the required information about the project; completely accurate.	Provides required information about the project; mostly accurate.	Provides most of the required information about the project; mostly accurate.	Provides some of the required information about the project; some major errors.	Provides little to none of the required information about the project; major errors.
<b>Presentation Skills</b>	Ideas are presented very clearly and visuals were very helpful to audience.	Ideas are presented clearly and visuals were helpful to audience.	Ideas are presented somewhat clearly and visuals were somewhat helpful to audience.	Ideas are mostly unclear and visuals were mostly unhelpful to audience.	Ideas are not presented clearly and visuals were not helpful to audience.

**Assessment Rubrics for Project**

	<b>Exceptional (5)</b>	<b>Effective (4)</b>	<b>Acceptable (3)</b>	<b>Developing (2)</b>	<b>Unsatisfactory (1)</b>
<b>Quality of the project</b>	Demonstrates exceptional competency in all the learning outcomes; very efficient and effective execution of the project; design meets objectives and demonstrates potential beyond the existing conditions; excellent problem solving.	Demonstrates competency in all the learning outcomes; efficient and effective execution of the project; design meets objectives but is limited to the existing conditions; appropriate problem solving.	Demonstrates sufficient competency in all the learning outcomes; somewhat efficient and effective execution of the project; design meets most of the objectives within the existing conditions; moderate problem solving.	Demonstrates some but insufficient competency in all the learning outcomes; somewhat inefficient and ineffective execution of the project; design does not meet most of the objectives within the existing conditions; some problem solving.	Demonstrates little to no competency in all the learning outcomes; inefficient and ineffective execution of the project; design does not meet any of the objectives within the existing conditions; limited to no problem solving.
<b>Teamwork</b>	Responsibilities were well-distributed and coordinated.	Responsibilities were distributed and coordinated.	Responsibilities were distributed but shows lack of coordination.	Responsibilities were not well-distributed or coordinated.	Responsibilities were not distributed or coordinated.

Name: \_\_\_\_\_

Learning Outcome Checklist page 1

		Rating*	Sign / Date
	<b>3D Printing [Individual]</b>	1 2 3 4 5	
1.	Basic overall knowledge about 3D printing and applications (Quiz)		
2.	Able to use a 3D drawing software:		
	to sketch, scale, position basic 2d sketches		
	to sketch, scale, position basic geometrical 3d objects		
	to combine 2 or more geometrical 3d objects into complex objects		
	to create assemblies of well-tolerant 3d components		
3.	Basic understanding of settings/parameters for 3d printing:		
	Layer Height and Resolution		
	Optimizing Orientation and Strength		
	Overhangs and Supports		
	Generation of 3D Print File from STL File		
4.	Post processing		
	Combining separate parts into single piece		
	Surface finishing techniques		
	Paint or colour application		
	Part duplication		
5.	Basic troubleshooting skills		
	Adjustments to increase load strength		
	Adjustments to improve print quality		
	Adjustments to reduce print time		
	<b>Computer Controlled Electronics using Arduino [Pair]</b>		
1.	Arduino programming language		
	if/then/else, while/for, setup/loop		
	DigitalWrite, AnalogWrite, DigitalRead, AnalogRead, delay		
	Debugging using Serial I/O		
2.	Digital input/output		
	Able to control LED lights (turn on/off, to blink, to light up in a certain sequence)		
3.	Analog input		
	Measure temperature using temperature sensor TMP36		
	Measure distance with ultrasonic sensor		
4.	Pulse Width Modulation (PWM)		
	Working with photoresistor and control LED brightness		
	Control speed of motor		

\* 5 – Done perfectly; 4 – Done a very good job but still have some room for improvement;  
3 – Completed the job but some improvements can be made;  
2 – Completed the job but some major improvements can be made; 1 – Unsatisfactory;

Name: \_\_\_\_\_

Learning Outcome Checklist page 2

		Rating*	Sign / Date
	<b>Mechanical Workshop [Individual]</b>	1 2 3 4 5	
1.	Demonstrate understanding and awareness of the safety in a mechanical workshop.		
2.	To be able to prepare a drill, drill a hole in a piece of Aluminium (~3 mm thick) and change the drill bit.		
3.	To be able bend a sheet of Aluminium into L-shape.		
4.	Using (2) and (3), make a simple useful object such as simple book stand or toothbrush holder.		
5.	Demonstrate understanding of the functionalities and basic operational principles of CNC machine and 3D metal printer.		
	<b>Electronics Workshop [Individual]</b>		
1.	Demonstrate understanding and awareness of the safety in an electronics workshop.		
2.	To be able to assembly electrical components onto PCB.		
3.	To be able to test and trouble system assembled on PCB.		
4.	Demonstrate understanding of the functionalities of circuit design and simulation software.		
5.	Demonstrate understanding of the functionalities and basic operational principles of PCB machine.		
	<b>Project [Pair]**</b>		
	<b>Project Presentation [Pair]**</b>		

\* 5 – Done perfectly; 4 – Done a very good job but still have some room for improvement;  
 3 – Completed the job but some improvements can be made;  
 2 – Completed the job but some major improvements can be made; 1 – Unsatisfactory;  
 [You will need to get at least a rating of 2 for all items to pass.]

\*\* Refer to Assessment Rubrics in the following page. [You will need to get at least a rating of 3 to 5 for all items for Project and Project presentation to pass.]

**Assessment Rubrics for Project Presentation**

	<b>Exceptional (5)</b>	<b>Effective (4)</b>	<b>Acceptable (3)</b>	<b>Developing (2)</b>	<b>Unsatisfactory (1)</b>
<b>Content</b>	Provides more than the required information about the project; completely accurate.	Provides required information about the project; mostly accurate.	Provides most of the required information about the project; mostly accurate.	Provides some of the required information about the project; some major errors.	Provides little to none of the required information about the project; major errors.
<b>Presentation Skills</b>	Ideas are presented very clearly and visuals were very helpful to audience.	Ideas are presented clearly and visuals were helpful to audience.	Ideas are presented somewhat clearly and visuals were somewhat helpful to audience.	Ideas are mostly unclear and visuals were mostly unhelpful to audience.	Ideas are not presented clearly and visuals were not helpful to audience.

**Assessment Rubrics for Project**

	<b>Exceptional (5)</b>	<b>Effective (4)</b>	<b>Acceptable (3)</b>	<b>Developing (2)</b>	<b>Unsatisfactory (1)</b>
<b>Quality of the project</b>	Demonstrates exceptional competency in all the learning outcomes; very efficient and effective execution of the project; design meets objectives and demonstrates potential beyond the existing conditions; excellent problem solving.	Demonstrates competency in all the learning outcomes; efficient and effective execution of the project; design meets objectives but is limited to the existing conditions; appropriate problem solving.	Demonstrates sufficient competency in all the learning outcomes; somewhat efficient and effective execution of the project; design meets most of the objectives within the existing conditions; moderate problem solving.	Demonstrates some but insufficient competency in all the learning outcomes; somewhat inefficient and ineffective execution of the project; design does not meet most of the objectives within the existing conditions; some problem solving.	Demonstrates little to no competency in all the learning outcomes; inefficient and ineffective execution of the project; design does not meet any of the objectives within the existing conditions; limited to no problem solving.
<b>Teamwork</b>	Responsibilities were well-distributed and coordinated.	Responsibilities were distributed and coordinated.	Responsibilities were distributed but shows lack of coordination.	Responsibilities were not well-distributed or coordinated.	Responsibilities were not distributed or coordinated.