MNE4048: ADVANCED MANUFACTURING TECHNOLOGIES

Effective Term
Semester A 2022/23

Part I Course Overview

Course Title
Advanced Manufacturing Technologies

Subject Code
MNE - Mechanical Engineering
Course Number
4048

Academic Unit
Mechanical Engineering (MNE)

College/School
College of Engineering (EG)

Course Duration
One Semester

Credit Units
3

Level
B1, B2, B3, B4 - Bachelor's Degree

Medium of Instruction
English

Medium of Assessment
English

Prerequisites
MBE2003/MNE2003 Mechanics or
MBE2040/MNE2040 Basic Mechanical Engineering Principles or
MBE2109/BME2109/MNE2109 Engineering Mechanics
AND
MBE2034/MNE2034 Engineering Materials and Processing or
MBE2110/MNE2110 Engineering Materials
AND
MBE3006/MNE3006 Plastics Engineering or
MBE3050/MNE3050 Design for Manufacturing and Manufacturing Systems or
MBE3119/MNE3119 Manufacturing Technology

Precursors
Nil

Equivalent Courses

MBE4048 Advanced Manufacturing Technologies

Exclusive Courses

Nil

Part II Course Details

Abstract

This course aims to introduce advanced manufacturing technologies that are affecting contemporary design for manufacture (DFM) practices. The aims of this course are to develop

- an understanding of a class of 3D printing and rapid prototyping (RP) technologies for rapid product development, including reverse engineering, 3D printing and additive manufacturing, and rapid tooling;
- and an holistic view of various applications of these technologies in relevant fields.

Key components to be covered include CAD issues for 3D printing and rapid prototyping, reverse engineering for model reconstruction from existing physical parts through digitizing and surface fitting, a class of additive manufacturing technologies for 3D printing and physical model prototyping, and rapid tooling for quick batch production.

Course Intended Learning Outcomes (CILOs)

	CILOs	Weighting (if app.)	DEC-A1	DEC-A2	DEC-A3
1	Describe various CAD issues for 3D printing and rapid prototyping and related operations for STL model manipulation.			x	
2	Formulate and solve typical problems on reverse engineering for surface reconstruction from physical prototype models through digitizing and spline-based surface fitting.			x	x
3	Formulate and solve typical problems on reverse engineering for surface reconstruction from digitized mesh models through topological modelling and subdivision surface fitting.			x	x
4	Explain and summarize the principles and key characteristics of additive manufacturing technologies and commonly used 3D printing and additive manufacturing systems.			x	
5	Explain and summarize typical rapid tooling processes for quick batch production of plastic and metal parts.			x	

A1: Attitude
Develop an attitude of discovery/innovation/creativity, as demonstrated by students possessing a strong sense of curiosity, asking questions actively, challenging assumptions or engaging in inquiry together with teachers.

A2: Ability
Develop the ability/skill needed to discover/innovate/create, as demonstrated by students possessing critical thinking skills to assess ideas, acquiring research skills, synthesizing knowledge across disciplines or applying academic knowledge to real-life problems.

A3: Accomplishments
Demonstrate accomplishment of discovery/innovation/creativity through producing /constructing creative works/new artefacts, effective solutions to real-life problems or new processes.

Teaching and Learning Activities (TLAs)

	TLAs	Brief Description	CILO No.	Hours/week (if applicable)
1	Lecture	Lectures covering three major areas on reverse engineering, 3D printing and additive manufacturing technologies, and rapid tooling.	1, 2, 3, 4, 5	2 hrs/week
2	Laboratory Work	Hands-on activities on reverse engineering, 3D printing and additive manufacturing processes, and rapid tooling.	1, 2, 3, 4, 5	3 hrs/week for 4 weeks

Assessment Tasks / Activities (ATs)

	ATs	CILO No.	Weighting (%)	Remarks (e.g. Parameter for GenAI use)
1	Test	2, 3	15	
2	Laboratory Exercises	1, 2, 3, 4, 5	25	4 sets of exercises; developed reports should be submitted by students

Continuous Assessment (%)

40

Examination (%)

60

Examination Duration (Hours)

2

Additional Information for ATs

For a student to pass the course, at least 30% of the maximum mark for both coursework and examination should be obtained.

Assessment Rubrics (AR)

Assessment Task

Test

Criterion

Ability to formulate and solve typical problems on reverse engineering, and to explain key concepts and methods on 3D printing and additive manufacturing processes.

Excellent (A+, A, A-)

High

Good (B+, B, B-)

Significant

Fair (C+, C, C-)

Moderate

Marginal (D)
Basic

Failure (F)
Not even reaching marginal levels

Assessment Task
Laboratory Exercises

Criterion
Familiarization with processes for 3D printing, additive manufacturing and rapid tooling and ability to solve typical problems in reverse engineering using selected digitizing and modelling solutions.

Excellent (A+, A, A-)
High

Good (B+, B, B-)
Significant

Fair (C+, C, C-)
Moderate

Marginal (D)
Basic

Failure (F)
Not even reaching marginal levels

Assessment Task
Examination

Criterion
Ability to formulate and solve typical problems on reverse engineering, and to explain key concepts, principles and methods on 3D printing, additive manufacturing technologies and rapid tooling.

Excellent (A+, A, A-)
High

Good (B+, B, B-)
Significant

Fair (C+, C, C-)
Moderate

Marginal (D)
Basic

Failure (F)
Not even reaching marginal levels

Additional Information for AR

Note: For a student to pass the course, at least 30% of the maximum mark for both coursework and examination should be obtained.

Part III Other Information

Keyword Syllabus

- Fundamentals of 3D printing and rapid prototyping (RP) technologies: various CAD issues for 3D printing and rapid prototyping, CAD and RP interfacing, triangular surface modelling and manipulation for 3D printing and additive manufacturing processes.
- Reverse engineering: digitizing, laser scanning, CT-scanning, point cloud manipulation, data segmentation, surface reconstruction, model further processing.
- Spline-based approaches for reverse engineering: various approaches for sample data parametrization, various approaches for knots allocation, spline surface fitting.
- Subdivision-based approaches for reverse engineering: topological modeling through mesh simplification, direct subdivision surface fitting, parametrization-based subdivision surface fitting.
- Liquid based processes for 3D printing and additive manufacturing: principles of stereolithography and typical processes, such as the SLA process, solid ground curing and others.
- Powder based processes for 3D printing and additive manufacturing: principles and typical processes, such as selective laser sintering and some other 3D printing processes.
- Solid based processes for 3D printing and additive manufacturing: principles and typical processes, such as fused deposition modelling, laminated object modelling and others.
- Rapid tooling: principles and typical processes for quick batch production of plastic and metal parts through quick tooling.

Reading List

Compulsory Readings

	Title
1	Nil

Additional Readings

	Title
1	Joseph J. Beaman, et. al., Solid Freeform Fabrication, Kluwer Academic Publishers, 1997.
2	Marshall Burns, Automated Fabrication, Prentice Hall, Englewood Cliffs, NJ, 1993.
3	Paul F. Jacobs, Stereolithography and other RP&M Technologies: from Rapid Prototyping to Rapid Tooling, Society of Manufacturing Engineers and the Rapid Prototyping Association, New York, 1996.
4	Chee Kai Chua and Kah Fai Leong, 3D Printing and Additive Manufacturing - Principles and Applications, The Fifth Edition of Rapid Prototyping: Principles and Applications World Scientific Publishing Co., 2017.
5	Victoria Zukas and Jonas A. Zukas, An Introduction to 3D Printing, First Edition Design Publishing, Inc., 2015.
6	D.T. Pham and S.S. Dimov, Rapid manufacturing: the Technologies and Applications of Rapid Prototyping and Rapid Tooling, Springer, London, 2001.
7	P.K. Venuvinod and Weiyin Ma, Rapid Prototyping – Laser-based and Other Technologies, Kluwer Academic Publishings, Boston, 2004.
8	T. Wohlers, 3D Printing and Additive Manufacturing State of the Industry, Annual Report, Wohlers Assoicates, 1996-2017.