Freie Universität Bozen
Libera Università di Bolzano
Università Liedia de Bulsan

Syllabus
Course description

Course title	Design and Manufacturing of Industrial Products
Course code	47552
Scientific sector	ING-IND/16 + ING-IND/15
Degree	Master Industrial Mechanical Engineering LM-33
Semester	1st
Year	1st
Academic Year	2021-2022
Credits	10 ECTS
Modular	Yes

Total lecturing hours	Module1: 28h lecture Module2: 24h lecture
Total lab hours	
Total exercise hours	Module1: 18h exercise Module2: 24h exercise
Attendance	Recommended
Prerequisites	None
Course page	https://www.unibz.it/en/faculties/sciencetechnology/master-industrial-mechanical-engineering/course-offering/

Specific educational objectives	The course is part of characterizing activities for engineering studies, and it is part of the curriculum of study of the Master in Industrial Engineering. The combination of theoretical findings and practical activities enables both the strengthening of students' scientific background and the acquisition of valuable professional skills. **Module 1** aims to furnish a general overview of the most important advanced technologies and manufacturing systems. At the end of the course, the student will be able to face a manufacturing problem deciding how to process and manage a product and choosing the suitable manufacturing technology (in particular with a focus on some specific advanced technologies such as Additive Manufacturing or Laser). **Module 2** addresses the fundamentals of methods and techniques to support engineering design processes, by focusing on the opportunities provided by Reverse Engineering and Rapid Prototyping. Students will achieve first a global understanding of product development processes. Then, the course will clarify the design phases and the circumstances in which Reverse Engineering and Rapid Prototyping are the most advantageous. Within the contents, a discussion about alternative technologies, which will be outlined as well, will be introduced. Students

	will have the opportunity to experience available tools in a lab setting.

Module 1	Advanced Manufacturing Technologies and Systems
Lecturer	Cristian Cappellini cristian.cappellini@unibz.it
Scientific sector of the lecturer	ING-IND/16
Teaching language	English
Office hours	Tuesday to Thursday, upon appointment to be agreed through email

List of topics covered	• Introduction to manufacturing,
	• CNC evolution,
	• Manufacturing systems,
	• Introduction to Industry 4.0,
	• Additive Manufacturing technologies targeting the production of end parts
	  ○ Powder Bed Fusion (PBF)
	  ○ Directed Energy Deposition (DED),
	• Hydroforming and Sheet incremental forming,
	• Laser,
	• Micromachining,
	• EBM,
	• EDM,
	DfMA and FMEA

Teaching format	Frontal lectures, exercises, case studies, group work (laptops are required for group work)

Module 2	Reverse Engineering and Rapid Prototyping
Lecturer	Yuri Borgianni
Scientific sector of the lecturer	ING-IND/15
Teaching language	English
Office hours	Monday to Friday, upon appointment to be agreed through email
Teaching assistant	Maccioni Lorenzo
Office hours	By appointment

List of topics covered	• Introduction to the Engineering Design process
	  ○ Support provided by established and emerging technologies to improve the design process
	• Reverse Engineering and 3D scanning
	  ○ Objectives and common application fields
	  ○ Existing technologies
	  ○ Contact systems
	  ○ Active non-contact systems
	  ○ Manipulation of acquired data
	  ○ Interface between Reverse Engineering and Computer-Aided Design systems
	  ○ Objectives and application fields of passive

	non-contact systems
	• Additive Manufacturing technologies targeting Rapid Prototyping
	  ○ Vat Photopolimerization, Stereolitography (SLA)
	  ○ Material Extrusion, Fused Deposition Modelling (FDM)
	  ○ Material Jetting
	  ○ Binder Jetting
	  ○ Sheet Lamination
	• Design for Additive Manufacturing
	• Employment of Reverse Engineering and Rapid Prototyping technologies in different industrial fields
	• Other technologies for the prototyping and the evaluation of products
	  ○ Use of Virtual Reality in engineering design
	Biometric systems, eye tracking

Teaching format	The module is based on frontal lectures, classroom and laboratory activities. Excursions and/or expert speeches are foreseen aimed to interact with industrial subjects, especially South Tyrolean companies, relevant for the course topics, e.g. 3D scanners and printers. The topics of the module are reported in the provided lecture notes, as well as in the textbooks of the bibliography and some scientific articles. Before each lecture, the corresponding .pdf presentation will be uploaded in the Open Learning Environment platform. The lecturer can be contacted by students for questions and clarifications by appointment. Discussion during lectures is fostered.

Learning outcomes	**Intended Learning Outcomes (ILO)** **Module 1** <u>Knowledge and understanding</u> 1. This module provides bases and opportunities to originally develop and/or apply knowledge and ideas both in a manufacturing and in a research context. <u>Applying knowledge and understanding</u> 2. Knowledge provided by the lessons will be applied in the development of a project connected to the studied technologies. <u>Making judgements</u> 3. This module provides the ability to integrate knowledge and handle complexity, and to formulate

global judgements as well as specific technologic analysis, evaluating the most suitable production cycle also for complex parts by using advanced technologies.

Communication skills

4. This module provides the ability for the students to work in group and communicate these conclusions both to specialist and non-specialist audiences.

Ability to learn

5. All the arguments are presented and discussed during the lectures. The study is autonomous and the students will have the possibility to discuss the achieved knowledge in the development of team course project.

Module 2

Knowledge and understanding

6. Students will
   i. acquire basic knowledge about the main objectives pursued by Reverse Engineering and Rapid Prototyping tools, with a particular focus on their use to design and develop new engineering products;
   ii. understand the main differences, pros and cons of the alternative technologies to carry out design tasks supported by 3D-printing devices targeting Rapid Prototyping
   iii. acquire knowledge about some important Additive Manufacturing processes predominantly used for the fabrication of prototypes;
   iv. be able to identify the advantages and limitations of Reverse Engineering and Additive Manufacturing processes in the overall context of design, manufacturing and industrial engineering.

Applying knowledge and understanding

7. Students will have the chance to apply their knowledge to master processes involving Reverse Engineering, Rapid Prototyping and modelling techniques with a hands-on approach.

Making judgments

8. Students will be able to compare the existing tools that have been developed for 3D scanning and Rapid Prototyping. They will develop critical capabilities about the pros and cons regarding said instruments. In addition, they will be able to explain alternative strategies for achieving the results obtained through Reverse

Engineering and Rapid Prototyping within engineering design.

Communication skills

9. Students will have the ability to properly discuss the fundamentals of Reverse Engineering and Rapid Prototyping.

Ability to learn

10. Students will be able to combine the knowledge acquired during the course with respect to the theoretical background of the teaching, the experience gathered by means of lab tests and notions about trends in the field, gained through the recent literature in the domain.
Students will have the opportunity to extend the knowledge of the topics of the course by consulting scientific literature, specialized texts, practitioners' materials or websites that the lecturer will suggest during the course.

Assessment

Module1

Form	Length /duration	ILOs assessed
Presentation case study	30 minutes per group 1,5 hours	2,4,5
Oral	20 minutes	1,3

Module 2

Form	Length /duration	ILOs assessed
Written exam*	Max. 4 hours	6, 8, 9

Formative assessment

The group exercises in the classroom and in the laboratory through hands-on experiments, conversations with the lecturer and the performance in specific tasks would enable the assessment and evaluation of the students' ability to apply their knowledge and understanding of the topics (7.) covered during the course, as well as their achieved communication skills (9.).

Summative assessment

The final exam consists in a written test, which mainly assesses the knowledge and understanding of the topics of the course (6.). Specific questions and exercises are tailored to assess students' capabilities to make judgements and selections (8.), their learning skills (10.), as well as their understanding of the objectives of the practical activities (7.). To this respect, details are found in "Evaluation criteria" below.

	*In case a written exam cannot be held due to "force majeure" such as COVID-19 restrictions, the module leader reserves the right to hold an oral exam instead of the written exam.
Assessment language	English
Evaluation criteria and criteria for awarding marks	**Module 1** Oral exam (50%) and project report presentation (50%) • Relevant for oral exam: clarity of answers, ability to summarize, evaluate, and establish relationships between topics, use of drawing and scheme of the processes; • Relevant for project: ability to work in a team, creativity, skills in critical thinking, ability to identify new solutions using the described technologies **Module 2** The evaluation criteria of the exam are tailored to test the knowledge of the topics of the course, the clarity of the answers and the appropriateness of the language of the student, the pertinence and the relevance of the response and the autonomy of judgment, as well the capability of critically selecting alternatives for product development. Specific questions will aim to assess the ability of the student to present, communicate and discuss the detailed design phase of engineering design cycles, by favorably implementing Reverse Engineering and Rapid Prototyping techniques. Other questions will verify the student's comprehension of the main practical issues emerged during practical activities, for instance the motivations behind the need to perform auxiliary functions to the scope of successful 3D scanning and printing operations. Additional exercises will be oriented to the evaluation of the skills concerning making of judgements, by proposing potential industrial problems and asking for the most appropriate technologies that might aid in the overcoming of said problems. In the written test, the points achievable by positively completing each exercises and answering each question will be clearly indicated. Points might be subtracted if the quality of the language will be not considered satisfactory, with specific reference to the terms characterizing the teaching. *Please note that the final mark for the course "Design and Manufacturing of Industrial Products" will be the average of the marks achieved in the modules "Reverse Engineering and Rapid Prototyping" and "Advanced Manufacturing Technologies and Systems"*

Required readings	Slides of the course The course material is mainly collected from research papers and web notes.
Supplementary readings	**Whole course** Gibson I, Rosen D, Stucker B, Additive Manufacturing Technologies, Springer. **Module 1** Boothroyd G, Dewhurst P, Knight WA, Production Design for Manufacture and Assembly, Taylor & Francis Group. Hassan E, Advanced Machining Process, McGraw Hill **Module 2** Raja, Vinesh, Fernandes, Kiran J. (Eds.), "Reverse Engineering: an Industrial Perspective", Springer *Additional textbooks, lecture notes, and research papers will be suggested by the lecturer during the course to enable student's autonomous study of pertinent topics.*