

Course guide

240073 - 240073 - Manufacturing Systems

Last modified: 16/05/2023

Unit in charge: Barcelona School of Industrial Engineering
Teaching unit: 712 - EM - Department of Mechanical Engineering.

Degree: BACHELOR'S DEGREE IN INDUSTRIAL TECHNOLOGY ENGINEERING (Syllabus 2010). (Compulsory subject).

Academic year: 2023 **ECTS Credits:** 4.5 **Languages:** Catalan, Spanish

LECTURER

Coordinating lecturer: Irene Buj Corral

Others:

PRIOR SKILLS

Basic knowledge of industrial technologies.

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:

1. Knowledge applied to manufacturing systems and processes, metrology and quality control.

Transversal:

2. SELF-DIRECTED LEARNING. Detecting gaps in one's knowledge and overcoming them through critical self-appraisal. Choosing the best path for broadening one's knowledge.
3. TEAMWORK. Being able to work as a team player, either as a member or as a leader. Contributing to projects pragmatically and responsibly, by reaching commitments in accordance to the resources that are available.

TEACHING METHODOLOGY

In-person teaching load of the subject is 4.5 credits, from which 2.7 are theoretical and 1.8 are practical. From the 1.8 practical credits, 0.8 correspond to exercises and practical problems done at class and 1.0 correspond to practical sessions in the laboratory. During the week there are two class sessions, of 1.5 h each, along which both theoretical credits and exercises and practical problems credits are done, without distinguishing between theory and problems class. For 10 weeks, each laboratory class group has one laboratory class session of 2 h every two weeks.

In the theory and exercises classes the different lessons are introduced, illustrated with examples and, in many cases, specific problems are raised and solved, in order to help to understand the concepts. Regarding the problems, in class standard exercises or problems of each lesson are raised and solved. Afterwards, some more exercises or problems are raised to be answered by the students at home, so that students can practice and assimilate the content. In practical laboratory sessions equipment, machines and elements corresponding to the topics of the course are observed in order to assimilate the content. In many laboratory sessions multimedia material is used so as to introduce the subject to be treated. There are five sessions in the Laboratory:

1. Metrology and verification of workpieces. (2h)
2. Turning and grinding of cylindrical surfaces. (2h)
3. Milling, drilling and grinding of flat surfaces. (2h)
4. Fixture of parts in the machine-tools. (2h)
5. Additive manufacturing. (2h)

The laboratory sessions are done in the Manufacturing Technologies Laboratory, pavilion D, floor -1, and in the laboratory session 5 the students also visit CIM Centre Foundation (UPC). At the end of each laboratory session, the students, in working groups, answer a questionnaire related to the content of each session, which is evaluated.



LEARNING OBJECTIVES OF THE SUBJECT

The objective of the subject is to provide the students with knowledge and skills that are necessary to identify, evaluate, compare and select different elements that allow designing the most suitable manufacturing and verification process as a function of the parts to be manufactured.

STUDY LOAD

Type	Hours	Percentage
Self study	67,5	60.00
Hours large group	35,0	31.11
Hours small group	10,0	8.89

Total learning time: 112.5 h

CONTENTS

1. Introduction to Manufacturing Systems

Description:

- 1.1 Concept of manufacturing process. Its situation within organization of the company.
- 1.2 Types of processes.
- 1.3 Technologies used for manufacturing workpieces.
- 1.4 Interrelations between product, function, shape, material and process.
- 1.5 Evolution of manufacturing. Conventional Factory and Factory of the Future.

Specific objectives:

To provide the students with knowledge and skills that are necessary to identify different types of basic manufacturing processes and their evolution.

Related activities:

Application exercises.

Related competencies :

CETI6. Knowledge applied to manufacturing systems and processes, metrology and quality control.
07 AAT. SELF-DIRECTED LEARNING. Detecting gaps in one's knowledge and overcoming them through critical self-appraisal.
Choosing the best path for broadening one's knowledge.

Full-or-part-time: 3h

Theory classes: 1h

Self study : 2h



2. Metrology and quality

Description:

- 2.1 Introduction.
- 2.2 Normalization.
- 2.3 ISO tolerance system.
- 2.4 Fittings.
- 2.5 Operations with dimensions.
- 2.6 Measuring methods. Measuring instruments, devices and machines.
- 2.7 Verification of parts. Callipers.
- 2.8 Quality control in the manufacturing process. Self-check.

Specific objectives:

To provide the students with knowledge and skills that are necessary to identify and explain all information in the drawings that is related to parts manufacturing and verifying, especially with regard to dimensional tolerances, geometric tolerances, and surface finish tolerances, regarding fittings and operations with dimensions. Providing the students with knowledge and skills that are necessary to identify, evaluate, compare and select: most usual metrology and verification instruments, and their functions, features and possibilities. To provide the students with knowledge and skills that are necessary to identify, evaluate, compare and select the most suitable quality control system as a function of the manufacturing process, and the functions, features and possibilities of above mentioned most suitable quality control system.

Related activities:

Practical exercises, application exercises, problems and videos. Laboratory session 1 in the Manufacturing Technology Laboratory of ETSEIB.

Related competencies :

CETI6. Knowledge applied to manufacturing systems and processes, metrology and quality control.
05 TEQ. TEAMWORK. Being able to work as a team player, either as a member or as a leader. Contributing to projects pragmatically and responsibly, by reaching commitments in accordance to the resources that are available.
07 AAT. SELF-DIRECTED LEARNING. Detecting gaps in one's knowledge and overcoming them through critical self-appraisal. Choosing the best path for broadening one's knowledge.

Full-or-part-time: 26h

Theory classes: 8h

Laboratory classes: 2h

Self study : 16h



3. Obtaining workpieces by metal cutting processes

Description:

- 3.1 Introduction.
- 3.2 Cutting tools.
- 3.3 Turning.
- 3.4 Milling.
- 3.5 Drilling.
- 3.6 Grinding.

Specific objectives:

To provide the students with knowledge and skills that are necessary to identify, evaluate, compare and select: different most appropriate elements that allow designing most suitable metal cutting process, as a function of type of workpieces, and functions, features and possibilities of above mentioned elements.

Related activities:

Practical exercises, application exercises, problems and videos. Laboratory sessions 2, 3 and 4 in the Manufacturing Technology Laboratory of ETSEIB.

Related competencies :

CETI6. Knowledge applied to manufacturing systems and processes, metrology and quality control.
05 TEQ. TEAMWORK. Being able to work as a team player, either as a member or as a leader. Contributing to projects pragmatically and responsibly, by reaching commitments in accordance to the resources that are available.
07 AAT. SELF-DIRECTED LEARNING. Detecting gaps in one's knowledge and overcoming them through critical self-appraisal. Choosing the best path for broadening one's knowledge.

Full-or-part-time: 40h

Theory classes: 12h

Laboratory classes: 4h

Self study : 24h

4. Obtaining moulded workpieces

Description:

- 4.1 Introduction.
- 4.2 Gravity casting..
- 4.3 Die casting.
- 4.4 Tolerances in different moulding systems..

Specific objectives:

To provide the students with knowledge and skills that are necessary to identify, evaluate, compare and select: different most appropriate elements that allow designing most suitable casting process as a function of type of workpieces, and functions, features and possibilities of above mentioned elements.

Related activities:

Practical exercises, application exercises, problems and videos.

Related competencies :

CETI6. Knowledge applied to manufacturing systems and processes, metrology and quality control.
07 AAT. SELF-DIRECTED LEARNING. Detecting gaps in one's knowledge and overcoming them through critical self-appraisal. Choosing the best path for broadening one's knowledge.

Full-or-part-time: 15h

Theory classes: 5h

Self study : 10h

5. Manufacture of parts by sintering processes

Description:

- 5.1 Introduction.
- 5.2 Steps of the sintering process.
- 5.3 Design of sintered parts.
- 5.4 Dimensional tolerances of parts obtained by sintering.

Specific objectives:

To provide the students with knowledge and skills that are necessary to identify most characteristic elements of the sintering process, with their functions and possibilities.

Related activities:

Videos.

Related competencies :

CETI6. Knowledge applied to manufacturing systems and processes, metrology and quality control.
05 TEQ. TEAMWORK. Being able to work as a team player, either as a member or as a leader. Contributing to projects pragmatically and responsibly, by reaching commitments in accordance to the resources that are available.
07 AAT. SELF-DIRECTED LEARNING. Detecting gaps in one's knowledge and overcoming them through critical self-appraisal. Choosing the best path for broadening one's knowledge.

Full-or-part-time: 5h

Theory classes: 1h

Laboratory classes: 2h

Self study : 2h

6. Forming workpieces by plastic deformation

Description:

- 6.1 Obtaining forged workpieces.
- 6.2 Obtaining extruded workpieces.
- 6.3 Obtaining metal sheet workpieces.
- 6.4 Tube manufacturing.

Specific objectives:

To provide the students with knowledge and skills that are necessary to identify, evaluate, compare and select: different most appropriate elements that allow designing most suitable plastic deformation process, as a function of type of workpieces, and functions, features and possibilities of above mentioned elements.

Related activities:

Practical exercises, application exercises, problems and videos.

Related competencies :

CETI6. Knowledge applied to manufacturing systems and processes, metrology and quality control.
07 AAT. SELF-DIRECTED LEARNING. Detecting gaps in one's knowledge and overcoming them through critical self-appraisal. Choosing the best path for broadening one's knowledge.

Full-or-part-time: 16h

Theory classes: 6h

Self study : 10h

7. Manufacture of plastic parts

Description:

- 7.1 Characteristics of plastics
- 7.2 Shaping of plastic materials

Specific objectives:

To provide the students with knowledge and skills that are necessary to identify most characteristic elements of the manufacture of plastic parts.

Related activities:

Videos.

Related competencies :

CETI6. Knowledge applied to manufacturing systems and processes, metrology and quality control.
05 TEQ. TEAMWORK. Being able to work as a team player, either as a member or as a leader. Contributing to projects pragmatically and responsibly, by reaching commitments in accordance to the resources that are available.
07 AAT. SELF-DIRECTED LEARNING. Detecting gaps in one's knowledge and overcoming them through critical self-appraisal. Choosing the best path for broadening one's knowledge.

Full-or-part-time: 5h

Theory classes: 1h
Laboratory classes: 2h
Self study : 2h

8. Additive manufacturing

Description:

- 8.1 Introduction.
- 8.2 Slurry based technologies
- 8.3 Powder based technologies.
- 8.4 Solid based technologies.

Specific objectives:

To provide the students with knowledge and skills that are necessary to identify most characteristic elements of the additive manufacturing processes, with their functions and possibilities.

Related activities:

Videos. Práctica de laboratorio 4.

Related competencies :

CETI6. Knowledge applied to manufacturing systems and processes, metrology and quality control.
07 AAT. SELF-DIRECTED LEARNING. Detecting gaps in one's knowledge and overcoming them through critical self-appraisal. Choosing the best path for broadening one's knowledge.

Full-or-part-time: 3h

Theory classes: 1h
Self study : 2h



ACTIVITIES

1. LABORATORY SESSION 1: METROLOGY AND VERIFICATION OF WORKPIECES

Description:

Introduction and use of basic metrology and verification instruments in a workshop. The students have to use the different measuring and verifying instruments for measuring and verifying different kinds of workpieces. The students work in groups and have to carry out a group of activities that are related to measurement and verification of workpieces and have to answer the questions of a questionnaire about result of these activities.

Specific objectives:

To provide the students with knowledge and skills that are necessary to identify, evaluate, compare, select and use the different basic elements for measurement and verification of parts.

Material:

Measurement and verification instruments for pieces in the Metrology Laboratory of ETSEIB. Vernier caliper, depth gauge, height gauge, micrometer, dial gauge, calipers, length gauges, marble platform, v block. Guiding notes of the laboratory session. PowerPoint for presentation of the content.

Delivery:

At the end of the laboratory class, in groups, the students give the answer of an exercise on the measurement of a certain part, which is evaluated and the mark obtained corresponds to 1/5 of the Mark of the Laboratory Sessions (NSL).

Related competencies :

CETI6. Knowledge applied to manufacturing systems and processes, metrology and quality control.

07 AAT. SELF-DIRECTED LEARNING. Detecting gaps in one's knowledge and overcoming them through critical self-appraisal. Choosing the best path for broadening one's knowledge.

05 TEQ. TEAMWORK. Being able to work as a team player, either as a member or as a leader. Contributing to projects pragmatically and responsibly, by reaching commitments in accordance to the resources that are available.

Full-or-part-time: 4h

Laboratory classes: 2h

Self study: 2h



2. LABORATORY SESSION 2: TURNING AND GRINDING CYLINDRICAL SURFACES

Description:

Machining cylindrical surfaces. Seeing different types of lathes, their operation, different kind of operations that can be performed, types of tools and their fixtures, types of workpieces that can be machined and different tool kits for fixing them. Seeing the grinding machine for cylindrical workpieces, its operation, types of workpieces that can be ground and their fixture. Seeing the documents that are necessary for manufacturing workpieces: list of operations and phase cycles. At the last part of the session the students, in work groups, will have to generate the necessary documentation for manufacturing a workpiece from its drawing. The students work as a team.

Specific objectives:

To provide the students with knowledge and skills that are necessary to identify, evaluate, compare and select the different elements for manufacturing revolution parts in the lathe or in the cylindrical grinding machine; and to generate documents that are necessary for manufacturing workpieces.

Material:

Machines and equipment of the Manufacturing Technology Workshop of ETSEIB. Revolver lathe with tools and tool kits. NC lathe. Cylindrical grinding machine with tools and tool kits. Guiding notes of the laboratory session. PowerPoint for presentation of the content.

Delivery:

At the end of the laboratory class, in groups, the students deliver a program of numerical control necessary for the manufacture of a piece, which are evaluated and the mark obtained corresponds to 1/5 of the Mark of the Laboratory Sessions (NSL).

Related competencies :

CETI6. Knowledge applied to manufacturing systems and processes, metrology and quality control.

05 TEQ. TEAMWORK. Being able to work as a team player, either as a member or as a leader. Contributing to projects pragmatically and responsibly, by reaching commitments in accordance to the resources that are available.

07 AAT. SELF-DIRECTED LEARNING. Detecting gaps in one's knowledge and overcoming them through critical self-appraisal. Choosing the best path for broadening one's knowledge.

Full-or-part-time: 4h

Laboratory classes: 2h

Self study: 2h



3. LABORATORY SESSION 3: MILLING, DRILLING AND GRINDING FLAT SURFACES

Description:

Machining flat surfaces. Seeing different types of milling machines, their operation, different kind of operations that can be performed, types of tools and their fixtures, types of workpieces that can be machined and different tool kits for fixing them. Seeing the drilling machine, its operation, types of operations, tools, types of workpieces that can be drilled and their fixture. Seeing the grinding machine for flat surfaces, its operation, types of operations, tools and their fixture, types of workpieces that can be ground and their fixture. Seeing the documents that are necessary for manufacturing workpieces: list of operations and phase cycles. At the last part of the session the students, in work groups, will have to generate the necessary documentation for manufacturing a workpiece from its drawing. The students work as a team.

Specific objectives:

To provide the students with knowledge and skills that are necessary to identify, evaluate, compare and select the different elements for manufacturing workpieces in the milling machine, drilling machine and grinding machine for flat surfaces; and to generate documents that are necessary for manufacturing workpieces.

Material:

Machines and equipment of the Manufacturing Technology Workshop of ETSEIB. Universal milling machine with tools and tool kits. NC milling machine. Drilling machine with tools and tool kits. Grinding machine for flat surfaces with tools and tool kits. Guiding notes of the laboratory session. PowerPoint for presentation of the content.

Delivery:

At the end of the laboratory class, in groups, the students deliver the CAM file of a program required for the manufacture of a part, and the mark obtained corresponds to 1/5 of the Grade of the Laboratory Sessions (NSL).

Related competencies :

CETI6. Knowledge applied to manufacturing systems and processes, metrology and quality control.

05 TEQ. TEAMWORK. Being able to work as a team player, either as a member or as a leader. Contributing to projects pragmatically and responsibly, by reaching commitments in accordance to the resources that are available.

07 AAT. SELF-DIRECTED LEARNING. Detecting gaps in one's knowledge and overcoming them through critical self-appraisal. Choosing the best path for broadening one's knowledge.

Full-or-part-time: 4h

Laboratory classes: 2h

Self study: 2h



4. LABORATORY SESSION 4: FIXTURE OF PARTS AT THE MACHINE TOOLS

Description:

Introduction to the concept of fixing parts. Fixing of revolution parts to the lathe and to the cylindrical grinding machine. Fixing prismatic parts to the milling machine, the drilling machine and the flat surface grinding machine.

In the second part of the session, the students, in work groups, will have to make the necessary roadmap for the manufacture of an example piece.

Specific objectives:

Provide students with the basic knowledge and skills needed to select the fixtures required to manufacture a certain part through chip removal processes.

Material:

Machines and equipment of the Manufacturing Technology Workshop of ETSEIB. Turning Centre, Milling Centre. Guiding notes of the laboratory session. PowerPoint for presentation of the content.

Delivery:

At the end of the laboratory session, in groups, the students deliver the Route Sheet that is necessary to manufacture a given part, and the mark obtained corresponds to 1/5 of the Grade of the Laboratory Sessions (NSL).

Related competencies :

CETI6. Knowledge applied to manufacturing systems and processes, metrology and quality control.

05 TEQ. TEAMWORK. Being able to work as a team player, either as a member or as a leader. Contributing to projects pragmatically and responsibly, by reaching commitments in accordance to the resources that are available.

07 AAT. SELF-DIRECTED LEARNING. Detecting gaps in one's knowledge and overcoming them through critical self-appraisal. Choosing the best path for broadening one's knowledge.

Full-or-part-time: 3h

Laboratory classes: 2h

Self study: 1h

5. LABORATORY SESSION 5: ADDITIVE MANUFACTURING

Description:

To see machines and to learn about the fused deposition modeling (FDM) technology, also known as fused filament fabrication (FFF).

Specific objectives:

To provide students with the knowledge and skills needed to print with FDM technology.

Material:

FDM machines. Plastic filament.

Delivery:

At the end of the laboratory session, in groups, the students give an example of the program required to print a certain piece, and the mark obtained corresponds to 1/5 of the Grade of the Laboratory Sessions (NSL).

Related competencies :

CETI6. Knowledge applied to manufacturing systems and processes, metrology and quality control.

05 TEQ. TEAMWORK. Being able to work as a team player, either as a member or as a leader. Contributing to projects pragmatically and responsibly, by reaching commitments in accordance to the resources that are available.

07 AAT. SELF-DIRECTED LEARNING. Detecting gaps in one's knowledge and overcoming them through critical self-appraisal. Choosing the best path for broadening one's knowledge.

Full-or-part-time: 3h

Laboratory classes: 2h

Self study: 1h



6. PARTIAL TEST

Description:

Theory questions, practical and application questions, exercises and problems.

Specific objectives:

To evaluate theoretical, practical and application knowledge acquired by students in the classes and other activities.

Material:

Teaching material of the subject.

Delivery:

Written test, which is evaluated and obtained qualification corresponds to Qualification of the Partial Test (NPP).

Related competencies :

CETI6. Knowledge applied to manufacturing systems and processes, metrology and quality control.

07 AAT. SELF-DIRECTED LEARNING. Detecting gaps in one's knowledge and overcoming them through critical self-appraisal.

Choosing the best path for broadening one's knowledge.

Full-or-part-time: 1h 15m

Theory classes: 1h 15m

7. FINAL EXAM

Description:

Theory questions, practical and application questions, exercises and problems.

Specific objectives:

To evaluate the theoretical, practical and application knowledge acquired by students in the classes and other activities.

Material:

Teaching material of the subject.

Delivery:

Written exam, which is evaluated and obtained qualification corresponds to Qualification of the Final Exam (NEF).

Related competencies :

CETI6. Knowledge applied to manufacturing systems and processes, metrology and quality control.

07 AAT. SELF-DIRECTED LEARNING. Detecting gaps in one's knowledge and overcoming them through critical self-appraisal.

Choosing the best path for broadening one's knowledge.

Full-or-part-time: 2h 30m

Theory classes: 2h 30m



8. FINAL INDIVIDUAL TEST OF THE LABORATORY SESSIONS

Description:

Questions of practical kind related to activities and content of the laboratory sessions.

Specific objectives:

To evaluate practical and application knowledge acquired by the students in the laboratory sessions.

Material:

Teaching material of the practical laboratory sessions.

Delivery:

Written test, which is evaluated and obtained qualification corresponds to Individual Qualification of the Laboratory Sessions (NIPL).

Related competencies :

CETI6. Knowledge applied to manufacturing systems and processes, metrology and quality control.

07 AAT. SELF-DIRECTED LEARNING. Detecting gaps in one's knowledge and overcoming them through critical self-appraisal. Choosing the best path for broadening one's knowledge.

Full-or-part-time: 0h 30m

Theory classes: 0h 30m

GRADING SYSTEM

Qualification is based on four types of evaluations: a partial test, a final exam, evaluation of questionnaires of laboratory sessions in groups and a final individual test about knowledge acquired in the laboratory sessions. In the partial test as well as in the final exam both theoretical and practical knowledge acquired in the classes as well as application knowledge from the rest of the sessions are evaluated. The laboratory sessions are evaluated by means of the questionnaire that the students answer in groups, at the end of each session. Comprehension degree, clear writing and presentation of the answers are evaluated. At the final individual test about laboratory sessions corresponding knowledge and skills acquired in the laboratory sessions are individually evaluated.

Algorithm for calculation of final qualification is as follows:

$$N_{\text{final}} = 0,1 \cdot \text{NSL} + 0,1 \cdot \text{NIPL} + 0,8 \cdot \text{Max}[\text{NEF}; 0,6 \cdot \text{NEF} + 0,4 \cdot \text{NPP}]$$

with: NSL: Qualification of the Laboratory Sessions. NIPL: Individual Qualification of the Laboratory Sessions. NEF: Qualification of the Final Exam. NPP: Qualification of the Partial Test.

Reevaluation:

The Reevaluation Exam corresponds to the content of theory and exercises of the subject. The obtained mark of the Reevaluation Exam NER replaces the marks NPP of the Partial Exam and NEF of the Final Exam.

$$N_{\text{final}} = 0,1 \cdot \text{NSL} + 0,1 \cdot \text{NIPL} + 0,8 \cdot \text{NER}$$

In order to be able to attend the reevaluation exam it is mandatory to previously attend the final exam of the subject.

Failure to attend the final exam of the subject implies a qualification of ABSENT.

EXAMINATION RULES.

Both in the partial test and in the final exam there is a theory and an exercise or problem part. In the theory part nothing can be taken. In the exercise or problem part, if necessary, it is possible to use a non-programmable calculator and the metrology tables. The reevaluation exam will only contain theory and exercises, not the laboratory class.

BIBLIOGRAPHY

Basic:

- Vivancos Calvet, J ; Buj Corral, I. ; Costa Herrero, Ll. Tecnologías de fabricación : colección de preguntas de teoría. Barcelona: Serveis Gràfics de Copisteria Imatge, 2012. ISBN 9788469564554.
- Vivancos Calvet, J. ; Buj Corral, I. ; Costa Herrero, Ll. Sistemas de Fabricación. Barcelona: Serveis Gràfics de Copisteria Imatge, 2013. ISBN 9788469584019.
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Complementary:

- Costa Herrero, Ll. ; Vivancos Calvet, J. Metrología y verificación : conceptos e instrumentos básicos. Barcelona: CPDA de la ETSEIB-UPC, 2006. ISBN 8495355973.
- Vivancos Calvet, J. Fabricación Asistida por Ordenador. Barcelona: ETSEIB. CDPA, 2007. ISBN 8496616231.
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- Buj Corral, I. ; Costa Herrero, Ll. ; González Rojas, H.A. ; Vivancos Calvet, J. Tecnologías de Fabricación II : Montajes, uniones, acabados de superficies y tratamientos térmicos. Barcelona: ETSEIB. CPDA, 2007. ISBN 8469916258.
- Vivancos Calvet, J. Tecnologías de Fabricación I : Procesos de Mecanizado. Barcelona: CPDA-Escola Tècnica Superior d'Enginyers Industrials de Barcelona, 2006. ISBN 8496616029.

RESOURCES

Other resources:

Powerpoint slides of the laboratory sessions.