240073 - Manufacturing Systems

**Coordinating unit:** 240 - ETSEIB - Barcelona School of Industrial Engineering  
**Teaching unit:** 712 - EM - Department of Mechanical Engineering  
**Academic year:** 2019  
**Degree:**  
- BACHELOR’S DEGREE IN MATERIALS ENGINEERING (Syllabus 2010). (Teaching unit Compulsory)  
- BACHELOR’S DEGREE IN CHEMICAL ENGINEERING (Syllabus 2010). (Teaching unit Compulsory)  
- BACHELOR’S DEGREE IN INDUSTRIAL TECHNOLOGY ENGINEERING (Syllabus 2010). (Teaching unit Compulsory)  
**ECTS credits:** 4,5  
**Teaching languages:** Catalan, Spanish

**Teaching staff**

**Coordinator:** Irene Buj Corral

**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.
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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. Basic Programming of Computerized Numerical Control Machine Tools. (2h)
5. Special Numerical Control Machines. Rapid Prototyping. Reverse Engineering. (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

<table>
<thead>
<tr>
<th>Total learning time: 112h 30m</th>
<th>Hours large group:</th>
<th>31.11%</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Hours small group:</td>
<td>8.89%</td>
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<tr>
<td></td>
<td>Guided activities:</td>
<td>0.00%</td>
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<tr>
<td></td>
<td>Self study:</td>
<td>60.00%</td>
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</tbody>
</table>
## 1. Introduction to Manufacturing Systems

**Learning time:** 3h  
Theory classes: 1h  
Self study: 2h

**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.  

**Related activities:**  
Application exercises.

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

## 2. Metrology and quality

**Learning time:** 26h  
Theory classes: 8h  
Laboratory classes: 2h  
Self study: 16h

**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.

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

**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.
3. Obtaining moulded workpieces

**Learning time:** 15h
- Theory classes: 5h
- Self study: 10h

**Description:**
- 3.1 Obtaining cast workpieces.
- 3.2 Obtaining plastic workpieces.
- 3.3 Obtaining workpieces by sintering.

**Related activities:**
Practical exercises, application exercises, problems and videos.

**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.

4. Forming workpieces by plastic deformation

**Learning time:** 16h
- Theory classes: 6h
- Self study: 10h

**Description:**
- 4.1 Obtaining forged workpieces.
- 4.2 Obtaining extruded workpieces.
- 4.3 Obtaining metal sheet workpieces.
- 4.4 Tube manufacturing.

**Related activities:**
Practical exercises, application exercises, problems and videos.

**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.
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## 5. Obtaining workpieces by metal cutting processes

<table>
<thead>
<tr>
<th>Description:</th>
<th>Learning time: 40h</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1 Introduction.</td>
<td></td>
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<tr>
<td>5.2 Cutting tools.</td>
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<td>5.3 Turning.</td>
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<td>5.4 Milling.</td>
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<td>5.5 Drilling.</td>
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<td>5.6 Grinding.</td>
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</table>

<table>
<thead>
<tr>
<th>Related activities:</th>
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<tbody>
<tr>
<td>Practical exercises, application exercises, problems and videos. Laboratory sessions 2 and 3 in the Manufacturing Technology Laboratory of ETSEIB.</td>
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</table>

<table>
<thead>
<tr>
<th>Specific objectives:</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>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.</td>
<td></td>
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</tbody>
</table>

## 6. Numerical Control (NC) and Computer Assisted Manufacturing (CAM)

<table>
<thead>
<tr>
<th>Description:</th>
<th>Learning time: 5h</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.1 Introduction.</td>
<td></td>
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<tr>
<td>6.2 Comparison between conventional machine and numerical control machine.</td>
<td></td>
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<tr>
<td>6.3 Historical references. Evolution of numerical controls and concepts.</td>
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<tr>
<td>6.4 Basic programming concepts.</td>
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<tr>
<td>6.5 CAM Systems.</td>
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<table>
<thead>
<tr>
<th>Related activities:</th>
<th></th>
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<tbody>
<tr>
<td>Basic numerical control programming exercises and videos. Laboratory session 4 in the Manufacturing Technology Laboratory of ETSEIB.</td>
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<table>
<thead>
<tr>
<th>Specific objectives:</th>
<th></th>
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<tbody>
<tr>
<td>To provide the students with knowledge and skills that are necessary to identify most characteristic elements of Numerical Control Machines and CAM systems, with their functions and possibilities.</td>
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</tbody>
</table>
7. Flexible Manufacturing Systems (FMS) and Computer Integrated Manufacturing (CIM)

**Description:**
- 7.1 Introduction.
- 7.2 Concepts.
- 7.3 Elements of Flexible Manufacturing.
- 7.4 Situation of Flexible Manufacturing compared to other production systems.
- 7.5 Computer Integrated Manufacturing (CIM).

**Related activities:**
- Videos.

**Specific objectives:**
To provide the students with knowledge and skills that are necessary to identify most characteristic elements of Flexible Manufacturing and Computer Integrated Manufacturing, with their functions and possibilities.

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8. Special processes

**Description:**
- 8.1 Sinker electro discharge machining.
- 8.2 Wire electro discharge machining.
- 8.3 Ultrasonic machining.
- 8.4 Laser cutting.
- 8.5 Waterjet cutting.
- 8.6 Rapid prototyping.

**Related activities:**
- Videos. Laboratory session 5 in the Manufacturing Technology Laboratory of ETSEIB and in Centre CIM Foundation.

**Specific objectives:**
To provide the students with knowledge and skills that are necessary to identify most characteristic elements of the studied special processes, with their functions and possibilities.
## Planning of activities

<table>
<thead>
<tr>
<th>Laboratory Session</th>
<th>Hours</th>
<th>Description</th>
<th>Support materials</th>
<th>Specific objectives</th>
</tr>
</thead>
</table>
| 1. LABORATORY SESSION 1: METROLOGY AND VERIFICATION OF WORKPIECES | 4h | **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. | **Support materials:**
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. | **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. |
| 2. LABORATORY SESSION 2: TURNING AND GRINDING CYLINDRICAL SURFACES | 4h | **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. | **Support materials:**
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. | **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. |
### 3. LABORATORY SESSION 3: MILLING, DRILLING AND GRINDING FLAT SURFACES

**Hours:** 4h
- Laboratory classes: 2h
- Self study: 2h

<table>
<thead>
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<tbody>
<tr>
<td>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.</td>
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<table>
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<tr>
<th>Support materials:</th>
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<table>
<thead>
<tr>
<th>Descriptions of the assignments due and their relation to the assessment:</th>
</tr>
</thead>
<tbody>
<tr>
<td>At the end of the laboratory session, in groups, the students deliver the list of operations and phase cycles for manufacturing a workpiece, which will be evaluated. Obtained qualification corresponds to 1/5 of the Qualification of Laboratory Sessions (NSL).</td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th>Specific objectives:</th>
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<tbody>
<tr>
<td>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.</td>
</tr>
</tbody>
</table>

### 4. LABORATORY SESSION 4: BASIC COMPUTER NUMERICAL CONTROL MACHINE TOOL PROGRAMMING

**Hours:** 3h
- Laboratory classes: 2h
- Self study: 1h

<table>
<thead>
<tr>
<th>Description:</th>
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<tr>
<td>Introduction to concepts and functions for Basic Numerical Control Programming, and introduction to operation of a Turning Centre and a Milling Centre. In the second part of the session, the students, in work groups, will have to prepare a Numerical Control Program for manufacturing a workpiece. The students work as a team.</td>
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<table>
<thead>
<tr>
<th>Support materials:</th>
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</thead>
<tbody>
<tr>
<td>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.</td>
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</table>

<table>
<thead>
<tr>
<th>Descriptions of the assignments due and their relation to the assessment:</th>
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<tbody>
<tr>
<td>At the end of the laboratory session, in groups, the students deliver the Control Numeric Program that is needed to obtain a workpiece, which will be evaluated. Obtained qualification corresponds to 1/5 of the Qualification of Laboratory Sessions (NSL).</td>
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<table>
<thead>
<tr>
<th>Specific objectives:</th>
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<tbody>
<tr>
<td>To provide the students with basic knowledge and skills that are necessary to generate Numerical Control Programs.</td>
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</table>
### 5. LABORATORY SESSION 5: SPECIAL NUMERICAL CONTROL MACHINES. RAPID PROTOTYPING. REVERSE ENGINEERING

**Description:**
Seeing special Numerical Control Machines: High speed vertical 5 axes Milling Centre, Machining Centre with indexing plate, 7 axes Multitasking Machine, Sinker Electro Discharge Machine (EDM), Wire Electro Discharge Machine (EDM), Stereolitography Rapid Prototyping Machine, Sintering Rapid Prototyping Machine, Coordinate Measuring Machine. Introduction to Reverse Engineering. At the final part of the sessions the students, in work groups, answer a questionnaire about machines and technologies that have been observed during the session. The students work as a team.

**Support materials:**

**Descriptions of the assignments due and their relation to the assessment:**
At the end of the laboratory session, in groups, the students deliver the answers to the questionnaire. They are evaluated and the obtained qualification corresponds to 1/5 of the Qualification of the Laboratory Sessions (NSL).

**Specific objectives:**
To provide the students with knowledge and skills that are necessary to identify Special Numerical Control Machines, Rapid Prototyping Machines and Reverse Engineering concepts.

### Hours
- Laboratory classes: 2h
- Self study: 1h
- Theory classes: 2h 30m
- Theory classes: 1h 15m

### 6. PARTIAL TEST

**Description:**
Theory questions, practical and application questions, exercises and problems.

**Support materials:**
Teaching material of the subject.

**Descriptions of the assignments due and their relation to the assessment:**
Written test, which is evaluated and obtained qualification corresponds to Qualification of the Partial Test (NPP).

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

### 7. FINAL EXAM

**Description:**
Theory questions, practical and application questions, exercises and problems.

**Support materials:**
Teaching material of the subject.
8. FINAL INDIVIDUAL TEST OF THE LABORATORY SESSIONS

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

**Support materials:**
Teaching material of the practical laboratory sessions.

**Descriptions of the assignments due and their relation to the assessment:**
Written test, which is evaluated and obtained qualification corresponds to Individual Qualification of the Laboratory Sessions (NIPL).

**Specific objectives:**
To evaluate practical and application knowledge acquired by the students in the laboratory sessions.

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### Qualification 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:
\[ N_{final} = 0.1 \cdot NSL + 0.1 \cdot NIPL + 0.8 \cdot \max\{NEF; 0.6 \cdot NEF + 0.4 \cdot NPP\} \]

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.
\[ N_{final} = 0.1 \cdot NSL + 0.1 \cdot NIPL + 0.8 \cdot NER \]

In order to 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.

### Regulations for carrying out activities

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. Within the final exam the individual test about laboratory sessions will be conducted. The reevaluation exam will only contain theory and exercises, not the laboratory class.
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Bibliography

Basic:


Complementary:


Others resources: