240073 - Manufacturing Systems

Coordinating unit: 240 - ETSEIB - Barcelona School of Industrial Engineering
Teaching unit: 712 - EM - Department of Mechanical Engineering
Academic year: 2017
Degree: BACHELOR'S DEGREE IN MATERIALS ENGINEERING (Syllabus 2010). (Teaching unit Compulsory)
BACHELOR'S DEGREE IN INDUSTRIAL TECHNOLOGY ENGINEERING (Syllabus 2010). (Teaching unit Compulsory)
BACHELOR'S DEGREE IN CHEMICAL 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.
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.

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: 35h</th>
<th>31.11%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hours medium group:</td>
<td>0h</td>
<td>0.00%</td>
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<tr>
<td>Hours small group:</td>
<td>10h</td>
<td>8.89%</td>
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<tr>
<td>Guided activities:</td>
<td>0h</td>
<td>0.00%</td>
</tr>
<tr>
<td>Self study:</td>
<td>67h 30m</td>
<td>60.00%</td>
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</tbody>
</table>
## Content

### 1. Introduction to Manufacturing Systems

<table>
<thead>
<tr>
<th>Learning time: 3h</th>
<th>Theory classes: 1h</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Self study: 2h</td>
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</tbody>
</table>

**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

<table>
<thead>
<tr>
<th>Learning time: 26h</th>
<th>Theory classes: 8h</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Laboratory classes: 2h</td>
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<tr>
<td></td>
<td>Self study: 16h</td>
</tr>
</tbody>
</table>

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

### Description:
- 5.1 Introduction.
- 5.2 Cutting tools.
- 5.3 Turning.
- 5.4 Milling.
- 5.5 Drilling.
- 5.6 Grinding.

### Related activities:
Practical exercises, application exercises, problems and videos. Laboratory sessions 2 and 3 in the Manufacturing Technology Laboratory of ETSEIB.

### 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.

### Learning time:
- Theory classes: 12h
- Laboratory classes: 4h
- Self study: 24h

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

### Description:
- 6.1 Introduction.
- 6.2 Comparison between conventional machine and numerical control machine.
- 6.3 Historical references. Evolution of numerical controls and concepts.
- 6.4 Basic programming concepts.
- 6.5 CAM Systems.

### Related activities:
Basic numerical control programming exercises and videos. Laboratory session 4 in the Manufacturing Technology Laboratory of ETSEIB.

### Specific objectives:
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.

### Learning time:
- Theory classes: 1h
- Laboratory classes: 2h
- Self study: 2h
### 7. Flexible Manufacturing Systems (FMS) and Computer Integrated Manufacturing (CIM) **Learning time:** 3h
- Theory classes: 1h
- Self study: 2h

**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.

### 8. Special processes **Learning time:** 5h
- Theory classes: 1h
- Laboratory classes: 2h
- Self study: 2h

**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

## 1. LABORATORY SESSION 1: METROLOGY AND VERIFICATION OF WORKPIECES

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

<table>
<thead>
<tr>
<th>Description:</th>
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<tbody>
<tr>
<td>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.</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Support materials:</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>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.</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Descriptions of the assignments due and their relation to the assessment:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>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).</td>
<td></td>
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</tbody>
</table>

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

## 2. LABORATORY SESSION 2: TURNING AND GRINDING CYLINDRICAL SURFACES

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

<table>
<thead>
<tr>
<th>Description:</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>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.</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Support materials:</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>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.</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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</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>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Specific objectives:</th>
<th></th>
</tr>
</thead>
<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 revolution parts in the lathe or in the cylindrical grinding machine; and to generate documents that are necessary for manufacturing workpieces.</td>
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</tbody>
</table>
# 3. LABORATORY SESSION 3: MILLING, DRILLING AND GRINDING FLAT SURFACES

<table>
<thead>
<tr>
<th>Description:</th>
<th>Hours: 4h</th>
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</table>
| 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. | Laboratory classes: 2h  
Self study: 2h |
| 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 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). | |
| 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. | |

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

<table>
<thead>
<tr>
<th>Description:</th>
<th>Hours: 3h</th>
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</thead>
</table>
| 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. | Laboratory classes: 2h  
Self study: 1h |
| Support materials: | |
| 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. | |
| Descriptions of the assignments due and their relation to the assessment: | |
| 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). | |
| Specific objectives: | |
| To provide the students with basic knowledge and skills that are necessary to generate Numerical Control Programs. | |
## 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), Stereolithography 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.

### 6. PARTIAL TEST

**Hours:** 1h 15m  
Theory classes: 1h 15m

**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

**Hours:** 2h 30m  
Theory classes: 2h 30m

**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.

Algorithm for calculation of final qualification is as follows:
\[ N_{\text{final}} = 0.1 \cdot N_{\text{SL}} + 0.1 \cdot N_{\text{NIPL}} + 0.8 \cdot \max \{N_{\text{EF}}; 0.6 \cdot N_{\text{EF}} + 0.4 \cdot N_{\text{PP}}\} \]


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.
\[ N_{\text{final}} = 0.1 \cdot N_{\text{SL}} + 0.1 \cdot N_{\text{NIPL}} + 0.8 \cdot N_{\text{ER}} \]

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.

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:
\[ N_{\text{final}} = 0.1 \cdot N_{\text{SL}} + 0.1 \cdot N_{\text{NIPL}} + 0.8 \cdot \max \{N_{\text{EF}}; 0.6 \cdot N_{\text{EF}} + 0.4 \cdot N_{\text{PP}}\} \]

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: