240AU311 - Integrated Manufacturing System

Coordinating unit: 240 - ETSEIB - Barcelona School of Industrial Engineering
Teaching unit: 712 - EM - Department of Mechanical Engineering
Academic year: 2019
Degree: ECTS credits: 3
Teaching languages: Catalan, Spanish

Teaching staff
Coordinator: Buj Corral, Irene
Others: Goma Ayats, Juan Ramon
           Costa Herrero, Luis

Prior skills
Basic knowledge in manufacturing.

Degree competences to which the subject contributes

Specific:
1. Conceptualize engineering models, apply innovative methods in problem solving and applications suitable for the
design, simulation, optimization and control of processes and systems
2. Integrate easily to interdisciplinary and creative technical team of any company in the automotive sector, research
center or laboratory tests

General:
3. Adapt to changes, being able to apply new and advanced technologies and other relevant processes, initiative and
entrepreneurship
4. Conceive, design, calculate and design processes, equipment, facilities and plants related to the design and
manufacture of vehicles and their systems

Teaching methodology
Learning methodology is based on five kinds of activities: Classes, Computer Laboratory, Metrology Laboratory,
Manufacturing Workshop and Semestral Work. In the classes, the teacher introduces the subject, provides concepts and
knowledge, and by means of practical exercises or application examples, helps to understand the content. In some
classes exercises or problems are proposed to be solved at home, which help to consolidate knowledge. Computer
Laboratory will be used to introduce use and application of some software that helps manufacturing parts or simulating
manufacturing processes. In the Metrology Laboratory use and application of computer assisted measurement and
verification instruments and machines will be introduced. In the Manufacturing Workshop use and application of different
kinds of numerical control machines will be introduced. At the end of the laboratory and workshop sessions the students
in groups will have to answer a set of questions about taught knowledge in the corresponding session. And, throughout
the semester, the students, organized in groups, will prepare a semestral work based on research and information
analysis about a subject, from which in the end they will have to write a report and do a PowerPoint presentation in order
to explain the subject to their class colleagues.

Learning objectives of the subject
The general objective of the subject is to provide students with knowledge and capabilities that are necessary to identify,
evaluate, compare and select most appropriate elements that allow integrating manufacturing systems. Basically
computer assisted elements used for manufacturing, which allow their integration, are treated.
240AU311 - Integrated Manufacturing System

<table>
<thead>
<tr>
<th>Study load</th>
<th>Hours medium group:</th>
<th>18h</th>
<th>24.00%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total learning time:</td>
<td>Hours small group:</td>
<td>9h</td>
<td>12.00%</td>
</tr>
<tr>
<td></td>
<td>Self study:</td>
<td>48h</td>
<td>64.00%</td>
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</tbody>
</table>
## 1. Numerical Control (NC) Machines

**Learning time:** 20h
- Theory classes: 8h
- Laboratory classes: 2h
- Self study: 10h

**Description:**
- Main features of NC. Basic Programming and Advanced Programming concepts. Types of NC machines.

**Related activities:**
- Advanced programming with NC exercises. Laboratory class 1 to see the manufacture of parts programmed with NC and different NC Machines in the Manufacturing Technology Workshop of ETSEIB and in CIM Centre Foundation (UPC).

**Specific objectives:**
- To provide students with knowledge and skills required to identify, evaluate, compare and select: basic elements that characterize numerical control machines, functions and features of CNC programming, applications and possibilities of numerical controls, and type of machinery where it can be applied.

## 2. Computer Aided Manufacturing (CAM)

**Learning time:** 15h
- Theory classes: 2h
- Laboratory classes: 4h
- Self study: 9h

**Description:**
- Introduction. Concepts. Types of CAM programs. Generation of NC programs using a CAM program. Other types of CAM programs to simulate metal sheet forming, forging, casting, plastic injection, etc.

**Related activities:**
- Exercises with MasterCam in the Computer Laboratory. Manufacture of workpieces in the Manufacturing Technology Workshop of ETSEIB.

**Specific objectives:**
- To provide students with knowledge and skills required to identify, evaluate, compare and select: functions and possibilities of CAM programs for generating numerical control programs, as well as functions and possibilities of CAM programs for simulating manufacturing processes.
### 3. Computer Aided Measurement and Verification

**Learning time:** 8h  
**Theory classes:** 2h  
**Laboratory classes:** 2h  
**Self study:** 4h

**Description:**  
Computer aided systems for measurement and verification of roughness, profiles, roundness, cylindricity, dimensional and positional errors. Roughness meter, profilometer, roundness/cylindricity measuring instrument, profile projector, laser interferometer, NC coordinate measuring machine.

**Related activities:**  
Laboratory class 2 to see different computer aided instruments, measurement and verification machines in the Metrology Laboratory of ETSEIB and in CIM Centre Foundation (UPC).

**Specific objectives:**  
To provide students with knowledge and skills required to identify, evaluate, compare and select: functions and possibilities of computer aided measuring and verifying instruments and machines.

### 4. Flexible Manufacturing

**Learning time:** 10h  
**Theory classes:** 4h  
**Self study:** 6h

**Description:**  

**Related activities:**  
Application exercises.

**Specific objectives:**  
To provide students with knowledge and skills required to identify, evaluate, compare and select: functions and possibilities of different elements that allow automated flexible manufacturing.
<table>
<thead>
<tr>
<th><strong>5. Computer Integrated Manufacturing (CIM)</strong></th>
<th><strong>Learning time:</strong> 6h</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>Theory classes: 2h</td>
</tr>
<tr>
<td>Introduction. Concepts. CAD-CAE-CAM-CAPP.</td>
<td>Self study : 4h</td>
</tr>
<tr>
<td>Control elements. SCADA systems. Reverse</td>
<td></td>
</tr>
<tr>
<td>Engineering. Virtual factory.</td>
<td></td>
</tr>
<tr>
<td><strong>Related activities:</strong></td>
<td></td>
</tr>
<tr>
<td>View videos on the topic.</td>
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</tr>
<tr>
<td><strong>Specific objectives:</strong></td>
<td></td>
</tr>
<tr>
<td>To provide students with knowledge and</td>
<td></td>
</tr>
<tr>
<td>skills required to identify, evaluate,</td>
<td></td>
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<tr>
<td>compare and select: functions and</td>
<td></td>
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<tr>
<td>possibilities of different elements that</td>
<td></td>
</tr>
<tr>
<td>allow computer integrated manufacturing.</td>
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</table>

| **6. Computer Aided Manufacturing Process** | **Learning time:** 6h |
| **Simulation**                             | Theory classes: 2h  |
| **Description:**                            | Self study : 4h     |
| Introduction. Concepts. Software for       |                     |
| simulating processes.                      |                     |
| **Related activities:**                    |                     |
| Practical exercise in the Computer Laboratory. |                 |
| **Specific objectives:**                   |                     |
| To provide students with knowledge and     |                     |
| skills required to identify, evaluate,     |                     |
| compare and select: functions and          |                     |
| possibilities of software that allows      |                     |
| simulation of processes.                   |                     |
### Planning of activities

| 1. Laboratory session 1: CAM software | Hours: 2h  
Laboratory classes: 2h |
<table>
<thead>
<tr>
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<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>To use CAM software in order to generate numerical control programs and simulate machining processes.</td>
</tr>
<tr>
<td><strong>Support materials:</strong></td>
<td>CAM software.</td>
</tr>
<tr>
<td><strong>Descriptions of the assignments due and their relation to the assessment:</strong></td>
<td>At the end of the laboratory session, the students, in groups, deliver a report about the laboratory class. Obtained mark corresponds to a part of the Qualification of Laboratory and Workshop Sessions (NLT).</td>
</tr>
<tr>
<td><strong>Specific objectives:</strong></td>
<td>To provide the students with knowledge and skills that are necessary to use CAM software to generate numerical control programs and their simulation.</td>
</tr>
</tbody>
</table>

| 2. Laboratory session 2: CAM software | Hours: 2h  
Laboratory classes: 2h |
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>Use of CAM software in order to generate numerical control programs and simulate machining processes.</td>
</tr>
<tr>
<td><strong>Support materials:</strong></td>
<td>CAM software.</td>
</tr>
<tr>
<td><strong>Descriptions of the assignments due and their relation to the assessment:</strong></td>
<td>At the end of the laboratory session, in groups, the students deliver a report, which is assessed. The qualification obtained corresponds to a part of the Qualification of Laboratory and Workshop Sessions (NLT).</td>
</tr>
<tr>
<td><strong>Specific objectives:</strong></td>
<td>To provide the students with knowledge and skills that are necessary to use CAM software to generate numerical control programs and their simulation.</td>
</tr>
</tbody>
</table>

| 6. Semestral work | Hours: 10h  
Self study: 10h |
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<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>To look for information and necessary features for selecting any of the studied elements, such as: a type of NC machine, a type of measuring or verifying machine, a software like CAM or a software for simulation of manufacturing processes, or any other element used for integrating manufacturing systems. It is a team work.</td>
</tr>
<tr>
<td><strong>Support materials:</strong></td>
<td>Information from the Internet and from the literature, journals, catalogues, papers, etc.</td>
</tr>
<tr>
<td><strong>Descriptions of the assignments due and their relation to the assessment:</strong></td>
<td>At the end of the semester a report must be submitted and an oral presentation must be made about the subject in front of classmates with the help of a PowerPoint. Both report and presentation are evaluated and the qualification obtained corresponds to the Qualification of Semestral Work (NTC).</td>
</tr>
</tbody>
</table>
# Specific objectives:
To provide the students with knowledge and skills that is necessary to identify, evaluate, compare and select: technical information that is necessary to select machines or equipment that are related to manufacturing and its integration. To provide skills to work in team and to write and present technical reports both in written and oral level.

## 7. Partial test

<table>
<thead>
<tr>
<th>Hours: 2h</th>
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<tbody>
<tr>
<td>Theory classes: 2h</td>
</tr>
</tbody>
</table>

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

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

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

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

## 8. Final exam

<table>
<thead>
<tr>
<th>Hours: 3h</th>
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</thead>
<tbody>
<tr>
<td>Theory classes: 3h</td>
</tr>
</tbody>
</table>

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

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

**Descriptions of the assignments due and their relation to the assessment:**
Written exam, which is evaluated and the qualification obtained corresponds to the Qualification of the Final Exam (NEF).

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

## 3. Laboratory session 3: CAM software

<table>
<thead>
<tr>
<th>Hours: 2h</th>
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<tbody>
<tr>
<td>Laboratory classes: 2h</td>
</tr>
</tbody>
</table>

**Description:**
Use of CAM software to generate numerical control programs and simulate the machining process.

**Support materials:**
CAM software.
### 4. Laboratory Session 4. Manufacturing of parts in a numerical control machine and verification of parts in a CN coordinate measuring machine.

**Description:**
To know how a Machining Centre works. Manufacturing of a workpiece of which students have generated corresponding numerical control program with CAM software. To see how tool presetting works. To measure the manufactured workpiece in a NC coordinate measuring machine.

**Support materials:**
- Machining Centre. Tool presetting machine. NC tridimensional coordinate measuring machine.

**Descriptions of the assignments due and their relation to the assessment:**
To provide the students with knowledge and skills that are necessary to use CAM software to generate numerical control programs and their simulation.

**Hours:** 2h  
Laboratory classes: 2h

### 5. Laboratory session 5. CAM software for design and simulation of moulds for plastic injection and dies for metal sheet stamping.

**Description:**
Use of a CAM software to generate numerical control programs and simulate plastic injection moulds and sheet stamping dies.

**Support materials:**
- CAM software.

**Descriptions of the assignments due and their relation to the assessment:**
At the end of the laboratory session, in groups, the students deliver a report of what they have seen in the laboratory session. Obtained mark corresponds to a part of the Mark of Laboratory and Workshop sessions (NLT).

**Specific objectives:**
To provide the students with knowledge of the possibilities of CAM software to design and simulate moulds for plastic injection and dies for metal sheet forming.

**Hours:** 2h  
Laboratory classes: 2h
240AU311 - Integrated Manufacturing System

Qualification system

Qualification is based on four types of evaluations: a partial test, a final exam, evaluation of laboratory and workshop sessions, and evaluation of the semestral work. In the partial test and the final exam theoretical and practical knowledge from the classes as well as application knowledge from the rest of the sessions are assessed. Laboratory and workshop sessions are evaluated from the questionnaire that the students will fill in at the end of every class, taking into account understanding degree, clear writing and presentation of the answers. In the class work, both the report, regarding content, structure, clearness and presentation, as well as the oral presentation to the colleagues, with help of Power Point, with content and clearness of the slides as well as quality of oral presentation will be evaluated.

Algorithm for calculation of final mark is:
N\text{final} = 0,1 \cdot \text{NLT} + 0,1 \cdot \text{NTC} + 0,8 \cdot \text{Max}[\text{NEF}; 0,6 \cdot \text{NEF} + 0,4 \cdot \text{NPP}]

with:  
\text{NLT}: Qualification of Laboratory and Workshop Sessions. \text{NTC}: Qualification of Semestral Work. \text{NEF}: Qualification of Final Exam. \text{NPP}: Qualification of Partial Test.

Regulations for carrying out activities

Nothing can be taken either to the theory part or to the exercises part of exams.

Bibliography

Complementary:


Others resources: