Degree competences to which the subject contributes

Specific:
1. Knowledge of the fundamentals of materials science, technology and chemistry. An understanding of the relationship between the microstructure, synthesis or processing and properties of materials.

Transversal:
2. EFFICIENT ORAL AND WRITTEN COMMUNICATION - Level 1. Planning oral communication, answering questions properly and writing straightforward texts that are spelt correctly and are grammatically coherent.
3. EFFECTIVE USE OF INFORMATION RESOURCES - Level 1. Identifying information needs. Using collections, premises and services that are available for designing and executing simple searches that are suited to the topic.

Teaching methodology

Participatory lectures. Solving exercises and problems.

Learning objectives of the subject

On completion of the subject, students must be able to:
- Recognise and classify different types of materials.
- Interpret the properties and results of tests of materials.
- Assess factors that affect behaviour.
- Choose or rule out forming processes in view of the material and requirements.
- Predict possible problems and propose improvements to be carried out in the application of materials for a specific purpose.
# Study load

<table>
<thead>
<tr>
<th>Total learning time: 150h</th>
<th>Hours large group:</th>
<th>45h</th>
<th>30.00%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hours medium group:</td>
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<td>0.00%</td>
</tr>
<tr>
<td></td>
<td>Hours small group:</td>
<td>15h</td>
<td>10.00%</td>
</tr>
<tr>
<td></td>
<td>Guided activities:</td>
<td>0h</td>
<td>0.00%</td>
</tr>
<tr>
<td></td>
<td>Self study:</td>
<td>90h</td>
<td>60.00%</td>
</tr>
</tbody>
</table>
## Content

### 1. ATOMS, MOLECULES AND BONDS

**Description:**
1.1. Atomic bonding  
1.2. Molecular bonding  
1.3. Classification of materials according to their bonding type

**Specific objectives:**
1.1. Classify materials according to their composition.  
1.2. Identify the dominant type of bond given the composition

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

### 2. STRUCTURE OF MATERIALS

**Description:**
2.2. Crystal structure of metals. Single-crystal and polycrystalline.  
2.3. Crystal structure of ceramics.  
2.4. Crystal structure of polymers.

**Specific objectives:**
2.1. Classify materials according to their composition and structure.  
2.2. Calculate the density of a crystalline metal or ceramic.  
2.3. Describe the nature of polymer crystals.  
2.4. Classify types of grain in metals.  
2.5. Determine the directional component (isotropy) in view of the crystal structure.  
2.6. Recognise the polymorphism and isomorphism of metals.

<table>
<thead>
<tr>
<th>Learning time:</th>
<th>3h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theory classes:</td>
<td>3h</td>
</tr>
</tbody>
</table>
# 3. IMPERFECTIONS IN THE CRYSTAL STRUCTURE

<table>
<thead>
<tr>
<th>Description:</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1. Imperfections in the structure of solids</td>
</tr>
<tr>
<td>3.2. Crystal imperfections of metals</td>
</tr>
<tr>
<td>3.3. Crystal imperfections of ceramics</td>
</tr>
<tr>
<td>3.4. Crystal imperfections of polymers</td>
</tr>
<tr>
<td>3.5. Non-crystalline structures</td>
</tr>
<tr>
<td>3.6. Microscopic observation, determination of grain size</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Related activities:</th>
</tr>
</thead>
<tbody>
<tr>
<td>A2, A7</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Specific objectives:</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1. Identify and classify crystal imperfections.</td>
</tr>
<tr>
<td>3.2. Calculate the density of interstitial and substitutional solid solutions.</td>
</tr>
<tr>
<td>3.3. Calculate the percentage of vacancies in a crystalline metal or ceramic.</td>
</tr>
<tr>
<td>3.4. Calculate the grain size index in a micrograph.</td>
</tr>
<tr>
<td>3.5. Describe the effect of crystalline imperfections on the plasticity of metals</td>
</tr>
</tbody>
</table>

**Learning time:** 2h
Theory classes: 2h
# 4. MECHANICAL PROPERTIES AND TESTS

<table>
<thead>
<tr>
<th>Learning time: 6h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theory classes: 6h</td>
</tr>
</tbody>
</table>

## Description:
- 4.1. Mechanical properties of metals
- 4.2. Properties obtained in tension-compression tests
  - 4.2.1. Elastic regime
  - 4.2.2. Plastic regime
- 4.3. Hardness
  - 4.3.1. Rockwell
  - 4.3.2. Vickers
  - 4.3.3. Brinell
  - 4.3.4. Mohs
- 4.4. Fracture toughness. Impact toughness
- 4.5. Fatigue behaviour
- 4.6. Hot behaviour

## Related activities:
- A2, A6

## Specific objectives:
- 4.1. Describe a tensile test.
- 4.2. Plot a stress-strain curve.
- 4.3. Using the data from a tensile test, calculate the following: elastic modulus, elastic limit, maximum strength, Poisson’s ratio, elongation, necking coefficient and strain hardening exponent.
- 4.4. Using partial data, calculate the following: elastic modulus, elastic limit, maximum strength, Poisson’s ratio, elongation, necking coefficient and strain hardening exponent.
- 4.5. Describe hardness tests HV, HB and HR.
- 4.6. Determine the differences, advantages and disadvantages of each one.
- 4.7. Calculate HB and HV from data or micrographs. Calculate maximum strength from HB.
- 4.8. Describe a fracture toughness test.
- 4.9. Calculate the critical stress for a given crack or the critical crack for a given level of stress.
- 4.10. Calculate the impact toughness.
- 4.11. Determine the ductile brittle transition temperature.
- 4.13. Calculate the fatigue life in a test.
- 4.15. Describe a creep test.
- 4.16. Calculate creep duration and velocity.
- 4.17. Describe the evolution of a creep curve as a function of temperature and applied stress.
### 5. DEFORMATION AND HARDENING MECHANISMS

**Description:**
5.1. Dislocation and plastic deformation  
5.2. Hardening mechanisms  
5.3. Grain size hardening  
5.4. Precipitation hardening  
5.5. Cold work hardening  
5.6. Heat treatment hardening

**Related activities:**  
A2, A3, A6, A7

**Specific objectives:**  
5.1. Describe the effect of crystal imperfections on the plasticity and movement of dislocations.  
5.2. Calculate the elastic limit as a function of grain size.  
5.3. Determine the effect of different types of alloys on mechanical behaviour.  
5.4. Calculate the percent cold work. Calculate the elastic limit, maximum strength and elongation as a function of % CW.  
5.5. Design the process of producing rolled steel from Ao to Af, taking into account elastic limit, maximum strength, Poisson's ratio and elongation requirements.  
5.6. Describe the annealing process.  
5.7. Describe the fundamentals of heat treatment hardening.

**Learning time:** 3h  
Theory classes: 3h

### 6. DIFFUSION

**Description:**
6.1. Diffusion mechanisms  
6.2. Fick's laws  
6.3. Diffusion and treatment of materials (applications)

**Specific objectives:**
6.1. Identify diffusion mechanisms and paths.  
6.2. Calculate parameters with Fick's first and second laws.  
6.3. Describe and recognise the main technological processes in which diffusion phenomena play a role.

**Learning time:** 3h  
Theory classes: 3h
# 7. PHASE DIAGRAMS

<table>
<thead>
<tr>
<th>Description:</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.1. Type of diagram and interpretation</td>
</tr>
<tr>
<td>7.2. Singular points</td>
</tr>
<tr>
<td>7.3. Fe-C diagram</td>
</tr>
<tr>
<td>7.3.1. Classification of steels</td>
</tr>
<tr>
<td>7.3.2. Classification of cast irons</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Related activities:</th>
</tr>
</thead>
<tbody>
<tr>
<td>A2, A7</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Specific objectives:</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.1. Interpret binary phase diagrams.</td>
</tr>
<tr>
<td>7.2. Calculate phases, compositions and quantities as a function of composition and temperature.</td>
</tr>
<tr>
<td>7.3. Describe the microstructural evolution of a cooling process.</td>
</tr>
<tr>
<td>7.4. Identify singular points.</td>
</tr>
<tr>
<td>7.5. Explain the technological importance of singular points.</td>
</tr>
<tr>
<td>7.6. Predict and calculate the structures in the Fe-C diagram.</td>
</tr>
<tr>
<td>7.7. Classify Fe-C alloys (steel and cast iron).</td>
</tr>
<tr>
<td>7.8. Describe their microstructure and possible behaviour.</td>
</tr>
<tr>
<td>7.9. Recognise the basic microstructures of Fe-C alloys.</td>
</tr>
<tr>
<td>7.10. Calculate the basic properties of normalised carbon steels.</td>
</tr>
</tbody>
</table>
### 8. HEAT TREATMENTS

**Description:**
- 8.1. Heat treatment of metals
- 8.2. Annealing
- 8.3. Quenching
- 8.4. Tempering
- 8.5. Precipitation and ageing
- 8.6. Thermochemical treatment of steels

**Related activities:**
A3

**Specific objectives:**
- 8.1. Interpret CCT and TTT curves.
- 8.2. Determine the heat treatment of a steel as a function of CCT and TTT curves.
- 8.3. Determine the annealing temperature.
- 8.4. Determine the microstructure of a carbon steel from the composition and treatment curve.
- 8.5. Choose the cooling medium for a heat treatment.
- 8.6. Classify types of hardening and predict the final mechanical behaviour.
- 8.7. Plot the curve of a precipitation and ageing treatment of a given alloy.
- 8.8. Determine which hardening treatment can be applied to different alloys and in which composition and temperature ranges.
- 8.9. Describe the main thermochemical treatments, their effects and their application conditions

### 9. ELECTRICAL AND MAGNETIC PROPERTIES

**Description:**
- 9.1. Electrical behaviour and bonding
- 9.2. Conductors, dielectrics and semiconductors
- 9.3. Other electrical behaviours
- 9.4. Fundamentals of magnetism
- 9.5. Diamagnetism, paramagnetism and ferromagnetism

**Specific objectives:**
- 9.1. Classify a material according to its electrical behaviour.
- 9.2. Calculate conductivity, load, intensity of the electric field, etc. for electrical materials.
- 9.4. Classify a material according to its magnetic behaviour.
- 9.2. Calculate permeability, field density, dissipated energy, etc. for magnetic materials.
## 10. METALS

**Learning time:** 2h  
Theory classes: 2h

### Description:

10.1. Structure  
10.2. Properties  
10.3. Specific tests  
10.4. Forming processes

### Related activities:

A2

### Specific objectives:

10.1. Describe the main characteristics, applications, advantages and disadvantages of metals.  
10.2. Classify them according to different parameters.  
10.3. Predict their properties from their structure and treatment.  
10.4. Recognise the forming processes that are appropriate for these materials.

## 11. CERAMICS

**Learning time:** 2h  
Theory classes: 2h

### Description:

11.1. Structure  
11.2. Properties  
11.3. Specific tests  
11.4. Forming processes

### Specific objectives:

11.1. Describe the main characteristics, applications, advantages and disadvantages of ceramics.  
11.2. Recognise crystal imperfections.  
11.3. Determine parameters (melting temperature) in ternary diagrams.  
11.4. Choose a refractory material for a given process.  
11.5. Recognise the forming processes that are appropriate for the material.
## 12. POLYMERS

**Description:**
- 12.1. Structure
- 12.2. Properties
- 12.3. Specific tests
- 12.4. Forming processes

**Related activities:**
A4

**Specific objectives:**
- 12.1. Describe the main characteristics, applications, advantages and disadvantages of thermoplastics (TP), thermosets (TS) and elastomers (RB).
- 12.2. Classify a polymer as a TP, TS or RB.
- 12.3. Predict the degree of crystallinity.
- 12.4. Classify a copolymer.
- 12.5. Recognise additives and their effects.
- 12.6. Recognise the forming processes that are appropriate for these materials.

## 13. COMPOSITES

**Description:**
- 13.1. Structure
- 13.2. Properties
- 13.3. Specific tests
- 13.4. Forming processes

**Specific objectives:**
- 13.1. Describe the main characteristics, applications, advantages and disadvantages of composites.
- 13.2. Classify them according to their matrix/reinforcement, type of reinforcement and directional behaviour.
- 13.3. Calculate their properties from the quantities of reinforcement and matrix.
- 13.4. Recognise the forming processes that are appropriate for these materials.
### 14. CORROSION

**Learning time:** 2h  
Theory classes: 2h

<table>
<thead>
<tr>
<th>Description:</th>
</tr>
</thead>
</table>
| 15.1. Chemical and electrochemical corrosion  
15.2. Electrochemical cells  
15.3. Corrosion velocity  
15.4. Strategies for fighting and preventing corrosion  |  

| Related activities: | A4, A10  

<table>
<thead>
<tr>
<th>Specific objectives:</th>
</tr>
</thead>
</table>
| 15.1. Determine and classify electrochemical cells.  
15.2. Identify the main anodic and cathodic reactions.  
15.3. Design strategies for fighting corrosion in specific cases.  
15.4. Calculate the corrosion velocity using Faraday's law.  
15.5. Calculate a cathodic protection system. |
## Planning of activities

<table>
<thead>
<tr>
<th>1. SIMULATION PRACTICAL</th>
<th>Hours: 4h</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>Laboratory classes: 2h</td>
</tr>
<tr>
<td>LABORATORY PRACTICAL</td>
<td>Self study: 2h</td>
</tr>
<tr>
<td>Students devise an example finite element simulation.</td>
<td></td>
</tr>
</tbody>
</table>

**Support materials:**
Practicals book (available on the virtual campus)

**Descriptions of the assignments due and their relation to the assessment:**
At the end of the practical the corresponding assignment must be handed in.
The assessment of the assignment and the other activities are part of the assessment as specified in the corresponding section of the course guide.

**Specific objectives:**
Use a finite element software package.
Interpret the results of a finite element simulation

<table>
<thead>
<tr>
<th>2. METALLOGRAPHY PRACTICAL</th>
<th>Hours: 4h</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>Laboratory classes: 2h</td>
</tr>
<tr>
<td>LABORATORY PRACTICAL</td>
<td>Self study: 2h</td>
</tr>
<tr>
<td>In this practical students learn various applications of metallographic microscopy techniques. In the first part, they must use the microscope correctly and identify the microstructure of various ferrous alloys. In the second part, they must calibrate an eyepiece with a scale and take various measurements. In the third part, they must determine the grain size index from a micrograph they have prepared beforehand. At the end of the practical the corresponding assignment must be handed in. A hardness test will also be carried out.</td>
<td></td>
</tr>
</tbody>
</table>

**Support materials:**
Practicals book (available on the virtual campus)

**Descriptions of the assignments due and their relation to the assessment:**
At the end of the practical the corresponding assignment must be handed in.
The assessment of the assignment and the other activities are part of the assessment as specified in the corresponding section of the course guide.

Based on this practical and the corresponding topic, students must carry out Activity 4 (metallography problem).
### 3. HEAT TREATMENT PRACTICAL

**Description:**
LABORATORY PRACTICAL
Students carry out hardening and tempering heat treatments. They then compare the microstructure and hardness with an annealed sample.

**Support materials:**
Practicals book (available on the virtual campus)

**Descriptions of the assignments due and their relation to the assessment:**
At the end of the practical the corresponding assignment must be handed in.
The assessment of the assignment and the other activities are part of the assessment as specified in the corresponding section of the course guide.

**Specific objectives:**
On completion of the practical, students must be able to:
- Determine treatment temperatures and types of cooling.
- Relate microstructures to properties and types of treatment.
- Use basic sample preparation techniques.

<table>
<thead>
<tr>
<th>Hours</th>
<th>4h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laboraory classes</td>
<td>2h</td>
</tr>
<tr>
<td>Self study</td>
<td>2h</td>
</tr>
</tbody>
</table>

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### 4. CORROSION PRACTICAL

**Description:**
LABORATORY PRACTICAL
Students determine a galvanic salt water series, prepare various types of electrochemical cells and carry out the electrochemical deposition of a metal.

**Support materials:**
Practicals book (available on the virtual campus)
5. MECHANICAL TEST PRACTICAL

**Description:**
LABORATORY PRACTICAL
Students carry out tensile and flexural strength impact tests on various materials.

**Support materials:**
Practicals book (available on the virtual campus)

**Hours:** 10h
Laboratory classes: 2h
Self study: 8h

**Descriptions of the assignments due and their relation to the assessment:**
At the end of the practical the corresponding assignment must be handed in.
Carrying out the practical validates the result of the questionnaire (Activity 9).

**Specific objectives:**
On completion of the practical, students must be able to:
Determine a galvanic series.
Classify a corrosion cell.
Calculate the theoretical weight of electrolytic coating and performance in the practical case.

6. TENSILE TEST

**Description:**
Students are given a file containing real data of a tensile test and they must process them to carry out and hand in a report that follows the guidelines published in the virtual campus.

**Support materials:**
Video tutorial in UPCommons

**Hours:** 6h
Guided activities: 3h
Self study: 3h
### 7. IMAGE ANALYSIS

**Description:**
Students are sent a file containing various micrographs. Students are asked to quantify the phases present and take measurements using the GIMP image analysis software.

**Support materials:**
- Practicals book (available on the virtual campus)
- Video tutorials in UPCommons

**Description of the assignments due and their relation to the assessment:**
The assessment of the assignment and the other activities are part of the assessment as specified in the corresponding section of the course guide.

**Specific objectives:**
On completion of the activity, students must be able to:
- Quantify phases using image analysis.
- Take measurements using image analysis.
- Apply the Hall-Petch law.

**Hours:**
- Self study: 3h

---

### 8. METALLOGRAPHY

**Description:**
Students are sent a micrograph and they must calculate the grain size index and then the elastic limit of a metal using the Hall-Petch relation.

**Support materials:**
- Practicals book (available on the virtual campus)

**Description of the assignments due and their relation to the assessment:**
The assessment of the assignment and the other activities are part of the assessment as specified in the corresponding section of the course guide.

**Specific objectives:**
On completion of the activity, students must be able to:
- Calculate the strength, elastic limit, ductility, elastic modulus and hardening coefficient of a metal from tensile test data.

**Hours:**
- Self study: 3h
### 9. CORROSION PRACTICAL QUESTIONNAIRE

**Description:**
Questionnaire to assess progress in the corrosion practical

**Support materials:**
Practicals book (available on the virtual campus)

**Specific objectives:**
On completion of the activity, students must be able to:
- Determine the grain size index and find the average grain diameter.
- Apply the Hall-Petch law.

**Hours:**
Self study: 3h

<table>
<thead>
<tr>
<th>Description</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description:</td>
<td>3h</td>
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<tr>
<td>Support materials:</td>
<td></td>
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<tr>
<td>Descriptions of the assignments due and their relation to the assessment:</td>
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<tr>
<td>Specific objectives:</td>
<td></td>
</tr>
<tr>
<td>Self study:</td>
<td>3h</td>
</tr>
</tbody>
</table>

### 10. PROGRESS TEST I

**Description:**
Written test in which students must demonstrate their understanding of the knowledge they have acquired on the topics explained so far.

**Specific objectives:**
For students to consolidate the knowledge acquired so far.

**Hours:**
Theory classes: 3h
Self study: 18h

<table>
<thead>
<tr>
<th>Description</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description:</td>
<td>21h</td>
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<tr>
<td>Specific objectives:</td>
<td></td>
</tr>
<tr>
<td>Descriptions of the assignments due and their relation to the assessment:</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Description</th>
<th>Hours</th>
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</thead>
<tbody>
<tr>
<td>Description:</td>
<td>3h</td>
</tr>
<tr>
<td>Support materials:</td>
<td></td>
</tr>
<tr>
<td>Specific objectives:</td>
<td></td>
</tr>
<tr>
<td>Self study:</td>
<td>18h</td>
</tr>
</tbody>
</table>
### 11. INTEGRATION TEST

**Description:**
Written test in which students must demonstrate their understanding of the knowledge they have acquired on the topics explained so far. In the test they will have to relate their knowledge of various topics.

**Descriptions of the assignments due and their relation to the assessment:**
The assessment of the assignment and the other activities are part of the assessment as specified in the corresponding section of the course guide.

**Specific objectives:**
For students to consolidate the knowledge acquired so far and for them to hone their ability to relate topics to one another.

<table>
<thead>
<tr>
<th>Hours</th>
<th>31h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theory classes</td>
<td>3h</td>
</tr>
<tr>
<td>Self study</td>
<td>28h</td>
</tr>
</tbody>
</table>

### 12. PHASE DIAGRAM QUESTIONNAIRE

**Description:**
Questionnaire to assess progress in the corrosion practical

**Support materials:**
Class notes in the virtual campus

**Descriptions of the assignments due and their relation to the assessment:**
The assessment of the assignment and the other activities are part of the assessment as specified in the corresponding section of the course guide.

**Specific objectives:**
For students to consolidate their knowledge of phase diagrams.

<table>
<thead>
<tr>
<th>Hours</th>
<th>3h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self study</td>
<td>3h</td>
</tr>
</tbody>
</table>

### 13. EFFECTIVE USE OF INFORMATION RESOURCES

**Description:**
For students to find books, journals and articles in the catalogue and search engines. For students to become familiar with the services offered by UPC libraries and the Manresa University Campus Library in particular.

**Support materials:**
Class notes in the virtual campus

<table>
<thead>
<tr>
<th>Hours</th>
<th>3h 30m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laboratory classes</td>
<td>2h</td>
</tr>
<tr>
<td>Self study</td>
<td>1h 30m</td>
</tr>
</tbody>
</table>
### Descriptions of the assignments due and their relation to the assessment:
The assessment of the assignment and the other activities are part of the assessment as specified in the corresponding section of the course guide.

### Specific objectives:
For students to find books, journals and articles in the catalogue and search engines.
For students to become familiar with the services offered by UPC libraries and the Manresa University Campus Library in particular.

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<table>
<thead>
<tr>
<th>14. EFFECTIVE USE OF INFORMATION RESOURCES QUESTIONNAIRE</th>
<th>Hours: 2h</th>
<th>Self study: 2h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description:</td>
<td>Questionnaire to assess progress in Activity 13</td>
<td></td>
</tr>
<tr>
<td>Support materials:</td>
<td>Class notes in the virtual campus</td>
<td></td>
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</tbody>
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<table>
<thead>
<tr>
<th>15. EFFECTIVE USE OF INFORMATION RESOURCES ASSIGNMENT</th>
<th>Hours: 2h</th>
<th>Self study: 2h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description:</td>
<td>Bibliographic research assignment</td>
<td></td>
</tr>
<tr>
<td>Support materials:</td>
<td>Class notes in the virtual campus</td>
<td></td>
</tr>
</tbody>
</table>

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For students to find books, journals and articles in the catalogue and search engines.
For students to become familiar with the services offered by UPC libraries and the Manresa University Campus Library in particular.

For students to find information on a topic in three different formats (book, web page and article). For students to cite the sources they find correctly.
Qualification system

Marks are calculated using the following formula:

\[ N = N_t \times 0.80 + N_p \times 0.20 \]

where \( N \) is the final mark, \( N_t \) the theory mark and \( N_p \) the mark for the practicals. The latter two are calculated in the following way:

\[ N_t = A_{10} \times 0.36 + A_{16} \times 0.36 + A_{11} \times 0.28 \]
\[ N_p = (A_{15} \times 0.17 + A_6 \times 0.27 + A_8 \times 0.20 + A_{12} \times 0.16 + A_7 \times 0.20) \times L \]

\( A_{10}, A_{11}, \text{etc.} \) are the marks for activities 10, 11, etc.

\( L \) is the mark for the laboratory practicals.

Activities A13, A14 and A15 assess progress on the effective use of information resources competency.

Regulations for carrying out activities

All the activities are individual unless otherwise stated. To carry out the practicals students must have passed the questionnaire published in the virtual campus beforehand.

All reports must be submitted in ISO 9000 format.

They must be students' original work. Copying their content will be punished with a mark of Fail for the activity and the subject.
### Bibliography

#### Basic:


#### Complementary:


#### Others resources:

**Audiovisual material**

Video: Tutorial d’anàlisi d’imatge metal·logràfica amb EL GIMP. Available in UPCommons

**Computer material**

ANSYS: available in the computer rooms

GIMP. Free software available at http://www.softcatala.cat/. Available in the computer rooms

**Website**

Matter

Jominy: http://www.matter.org.uk/steelmatter/metallurgy/7_1_1

Hall-Petch: http://aluminium.matter.org.uk/content/html/eng/default.asp?catid=64&pageid=1000314345

Charpy: http://www.steeluniversity.org/content/html/eng/default.asp?catid=151&pageid=208127192