320052 - EF - Fluid Engineering

Coordinating unit: 205 - ESEIAAT - Terrassa School of Industrial, Aerospace and Audiovisual Engineering
Teaching unit: 729 - MF - Department of Fluid Mechanics
Academic year: 2018
Degree: BACHELOR'S DEGREE IN MECHANICAL ENGINEERING (Syllabus 2009). (Teaching unit Compulsory)
ECTS credits: 6
Teaching languages: Catalan, Spanish

Teaching staff

Coordinator: PEDRO JAVIER GAMEZ MONTERO

Others: ESTEVE CODINA MACIA
HIPOLIT MORENO

Prior skills

Students will be expected to have passed the second-year Fluid Mechanics subject in order to take Fluid Engineering.

Requirements

Degree competences to which the subject contributes

Specific:
3. MEC: Applied knowledge of the main systems and machines

Transversal:
1. SELF-DIRECTED LEARNING - Level 3. Applying the knowledge gained in completing a task according to its relevance and importance. Deciding how to carry out a task, the amount of time to be devoted to it and the most suitable information sources.
2. TEAMWORK - Level 3. Managing and making work groups effective. Resolving possible conflicts, valuing working with others, assessing the effectiveness of a team and presenting the final results.
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**Teaching methodology**

- Face-to-face lecture sessions.
- Face-to-face practical work sessions.
- Independent learning and exercises.
- Preparation and completion of group activities subject to assessment.

In the face-to-face lecture sessions, the lecturer will introduce the basic theory, concepts, methods and results for the subject and use examples to facilitate students' understanding. Practical class work will be covered in three types of sessions:
  a) Sessions in which the lecturer will solve problems on the blackboard using techniques, concepts and theoretical results by way of example (40%).
  b) Sessions in which the lecturer helps students analyse data and resolve problems (25%).
  c) Sessions in which students sit tests (20%).
  d) Sessions in which students give presentations of group work (5%).

Students will be expected to study in their own time so that they are familiar with concepts and are able to solve the exercises set, whether manually or with the help of a computer.

**Learning objectives of the subject**

**Theoretical knowledge**

In the Hydraulic Machines and Systems section:
- A basic understanding of the fundamental concepts of fluid machines and systems, their properties and the fundamental laws that govern them, as well as mathematical knowledge to support this understanding.

In the Oleohydraulic and Pneumatic Systems section:
- Technical capabilities in the area of specialisation.
- An understanding of the subject's scientific foundation.
- The ability to apply technology and engineering skills, in particular to do the following:
  - Assess advantages and disadvantages of the use of fluid power (either oleohydraulic or pneumatic).
  - Identify the various elements that comprise oleohydraulic and pneumatic energy-transfer systems.
  - Draw symbol-based diagrams and use software to represent and simulate systems.
  - Design an oleohydraulic or pneumatic installation capable of driving machines or mechanisms.

**Professional skills**

- The ability to analyse specific situations, define problems, make decisions and implement action plans in order to find solutions.
- The ability to apply knowledge acquired in real situations and properly manage the available resources, while taking steps to minimise the environmental impact (energy recovery, noise mitigation, reduction of fluid-based contamination, etc.).
- The ability to interpret studies, reports, data, regulations and European directives (lifecycle, safety, etc.).
- The ability to select and use information sources.
- The ability to use the available computer tools as support.
- The ability to work in a multidisciplinary team.
- The ability to value comprehensive training, personal motivation and mobility.

**Communication skills**

- The ability to understand and use the appropriate terminology.
- The ability to debate and put forth arguments in a variety of forums.

**Technology transfer skills**

- The ability to analyse and assess the environmental implications of their professional activity
- The ability to analyse and assess the social and ethical implications of their professional activity.
- A critical and innovative spirit.
- The ability to stay up-to-date on new technological advances by means of lifelong learning.
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Applied knowledge
- Students will put their knowledge into practice by solving standard problems that help to understand and build on the knowledge acquired.

Aptitudes and attitudes
- Students will discover the benefits of learning about fluid mechanics and its applications, which form part of our everyday lives at all levels.
- Students will likewise learn to work, discuss and summarise their findings in groups.

Study load

<table>
<thead>
<tr>
<th>Total learning time: 150h</th>
<th>Hours large group:</th>
<th>30h</th>
<th>20.00%</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Hours medium group:</td>
<td>15h</td>
<td>10.00%</td>
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<tr>
<td></td>
<td>Hours small group:</td>
<td>15h</td>
<td>10.00%</td>
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<tr>
<td></td>
<td>Guided activities:</td>
<td>6h</td>
<td>4.00%</td>
</tr>
<tr>
<td></td>
<td>Self study:</td>
<td>84h</td>
<td>56.00%</td>
</tr>
</tbody>
</table>
# Content

## TOPIC 1: General principles

**Learning time:** 4h  
Theory classes: 1h  
Self study: 3h

### Description:
1.1. Basic concepts of fluid mechanics.  
1.2. Basic principles.

### Related activities:
E - Applied exercises

### Specific objectives:
- Familiarity with the basic concepts of fluid mechanics.  
- The ability to interpret the basic principles of fluid mechanics.  
- The ability to use the basic principles of fluid mechanics.

## TOPIC 2: TURBOMACHINERY

**Learning time:** 18h  
Theory classes: 3h  
Practical classes: 2h  
Laboratory classes: 4h  
Self study: 9h

### Description:
2.1. Pumps.  
2.2. Fans.  
2.3. Characteristic curves.  
2.4. Selection.  
2.5. Areas of application.

### Related activities:
E - Applied exercises  
Practical P1. Centrifugal pump  
Practical P2. Fan  
2. Applied exercises

### Specific objectives:
- Describe pumps and fans.  
- Interpret characteristic curves.  
- Apply selection criteria.  
- Identify areas of application.  
- Interpret selections in terms of areas of application.
### TOPIC 3: ONE- AND TWO-DIMENSIONAL THEORIES

**Learning time:** 5h  
Theory classes: 1h  
Practical classes: 1h  
Self study : 3h

**Description:**
3.1. Euler triangles.  
3.2. Degree of reaction.

**Related activities:**
E - Applied exercises  
C - Test

**Specific objectives:**
- Describe and interpret Euler triangles.  
- Manipulate and calculate Euler triangles.  
- Define the degree of reaction.  
- Formulate and calculate the degree of reaction

### TOPIC 4: MODEL THEORY

**Learning time:** 9h  
Theory classes: 2h  
Practical classes: 1h  
Self study : 6h

**Description:**
4.1. Dimensional homogeneity and dimensionless groups.  
4.2. Similarity.

**Related activities:**
E - Applied exercises

**Specific objectives:**
- Identify the dimensional homogeneity of variables in a physical process expressed through an equation.  
- Identify dimensionless groups related to hydraulic machines.  
- Learn the basic dimensionless groups.  
- Apply similarity and the theory of models to standard problems
### TOPIC 5: TURBOMACHINERY INSTALLATIONS

**Learning time:** 25h  
Theory classes: 5h  
Practical classes: 3h  
Laboratory classes: 2h  
Self study: 15h

| Description: |  
| --- | --- |
| 5.1. Point of operation. |  
| 5.2. Regulation systems. |  
| 5.3. Control valves. |  
| 5.4. Selection. |  
| 5.5. Types. |  

| Related activities: |  
| --- | --- |
| E - Applied exercises |  
| Practical P3 - Control valve |  

| Specific objectives: |  
| --- | --- |
| - Determine the operating point. |  
| - Interpret regulation systems. |  
| - Identify and describe control valves. |  
| - Apply selection criteria. |  
| - Describe installation types. |
### TOPIC 6: UNSTABLE OPERATION

**Description:**
- 6.1. Water hammer.
- 6.2. Estimation of downtime.
- 6.3. Cavitation.

**Related activities:**
- E - Applied exercises
- C - Test
- Practical P4 - Water hammer

**Specific objectives:**
- Interpret and describe water hammer.
- Interpret and calculate estimated downtime.
- Describe the phenomenon of cavitation.
- Calculate limits of application to avoid cavitation.

### TOPIC 7: FLUID ENERGY TRANSFER SYSTEMS

**Description:**
- 7.1. Oil/oleohydraulics.
- 7.2. Air/pneumatics.
- 7.3. Strengths and weaknesses of these technologies.

**Related activities:**
- E - Applied exercises

**Specific objectives:**
- Understand the differences between oil/oleohydraulics and air/pneumatics.
- Be able to describe the strengths and weaknesses of each.
### TOPIC 8: BASIC COMPONENTS

**Learning time:** 5h  
- Theory classes: 1h  
- Laboratory classes: 1h  
- Self study: 3h

**Description:**  
8.2. Compressors.  
8.3. Pressure equipment and power sources.  
8.4. Basic installations (compressed-air treatment).

**Related activities:**  
E - Applied exercises  
Practical P5 - Morphology of positive displacement pumps

**Specific objectives:**  
- Describe the operating principle of positive displacement devices.  
- Describe the characteristics of pressure equipment and basic installations.

### TOPIC 9: OLEOHYDRAULIC AND PNEUMATIC REGULATION AND CONTROL ELEMENTS

**Learning time:** 10h  
- Theory classes: 2h  
- Laboratory classes: 2h  
- Self study: 6h

**Description:**  
9.1. Pressure-control valves.  
9.2. Flow-control valves.  
9.3. Directional-control valves.  
9.4. Characteristic curves.

**Related activities:**  
E - Applied exercises  
Practical P6 - Morphology of valves

**Specific objectives:**  
- Recognise the various types of valves.  
- Describe the various types of valves.  
- Interpret and explain the various types of valves and their basic structure  
- Identify and use the characteristic curves of valves.
## TOPIC 10: LINEAR AND ROTARY ACTUATORS

<table>
<thead>
<tr>
<th>Description:</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.2. Engines</td>
</tr>
<tr>
<td>10.3. Description of basic components: materials, guides, joints.</td>
</tr>
<tr>
<td>10.4. Basic characteristics (pre-design).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Related activities:</th>
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</thead>
<tbody>
<tr>
<td>E - Applied exercises</td>
</tr>
<tr>
<td>C - Test</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Specific objectives:</th>
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</thead>
<tbody>
<tr>
<td>- Recognise linear and rotary actuators.</td>
</tr>
<tr>
<td>- Describe cylinders and engines.</td>
</tr>
<tr>
<td>- Interpret and describe the basic components of actuators.</td>
</tr>
<tr>
<td>- Apply and calculate basic characteristics for pre-design</td>
</tr>
</tbody>
</table>

### Learning time: 8h
- Theory classes: 2h
- Self study: 6h
### TOPIC 11: BASIC PNEUMATIC AND OLEOHYDRAULIC CIRCUITS

**Description:**
- Pneumatics:
  1. Basic ideas.
  2. Circuits with sequence controllers.
  3. Electro-pneumatic circuits: control with relays, Grafcet and PLCs.
- Oleohydraulics:
  4. Open-centre and closed-centre circuits.
  5. Sequence control.
  6. Variable-speed profile control.
  7. Accumulator circuits.
  8. Regenerative circuits.
10. Load-sensing circuits.

**Related activities:**
- E - Applied exercises
- Practical P7 - Circuit assembly

**Specific objectives:**
- Identify basic pneumatic and oleohydraulic circuits and their various elements.
- Interpret basic pneumatic and oleohydraulic circuits.
- Manipulate basic oleohydraulic circuits.

**Learning time:** 21h
- Theory classes: 4h
- Practical classes: 5h
- Self study: 12h

### TOPIC 12: PRE-DESIGN OF BASIC CIRCUITS

**Description:**
- Basic circuits

**Related activities:**
- E - Applied exercises
- Practical P7 - Circuit assembly

**Specific objectives:**
- Calculate basic oleohydraulic circuits.
- Analyse basic oleohydraulic circuits.

**Learning time:** 16h
- Theory classes: 3h
- Practical classes: 2h
- Laboratory classes: 2h
- Self study: 9h
### TOPIC 13: DESIGN AND SIMULATION OF ELECTRONIC CIRCUITS

**Description:**
13.1. Simulation of the dynamic behaviour of basic circuits.

**Related activities:**
- E - Applied exercises
- Practical P8 - Computer simulation

**Specific objectives:**
- Use software to simulate the dynamic behaviour of basic circuits.
- Analyse the results obtained from the software simulation.

<table>
<thead>
<tr>
<th>Learning time: 3h</th>
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</thead>
<tbody>
<tr>
<td>Practical classes: 1h</td>
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<tr>
<td>Laboratory classes: 2h</td>
</tr>
</tbody>
</table>

### TOPIC 14: FLUID CONDITIONING AND TRANSPORT ELEMENTS

**Description:**
14.1. Fittings, pipes and flexible parts.
14.2. Water tanks
14.3. Filtration.
14.4. Temperature control.
14.5. Environmental aspects.

**Related activities:**
- E - Applied exercises
- C - Test

**Specific objectives:**
- Recognise the main fluid conditioning and transport elements.
- Describe and explain the basic characteristics and operation of the main fluid conditioning and transport elements.

<table>
<thead>
<tr>
<th>Learning time: 8h</th>
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<tbody>
<tr>
<td>Theory classes: 2h</td>
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<tr>
<td>Self study: 6h</td>
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</tbody>
</table>
# Planning of activities

## ACTIVITY 1: P1 - PUMP

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

**Description:**  
A pump is a machine that converts mechanical energy into hydraulic energy by working with a liquid. The objective of this lab is to experimentally obtain its characteristics curves: HB-Q, Nabs-Q and ΨB-Q.

**Support materials:**  
Lab guides and reports manual, instrumentation and laboratory equipment. Extra material can be uploaded in ATENEA

**Descriptions of the assignments due and their relation to the assessment:**  
Deliverable activity by writing the corresponding practice report to be evaluated. The evaluation mark is within the percentage of labs in the grade system of the course.

**Specific objectives:**  
Acquiring the ability to know, understand and apply the knowledge of the basic principles related to the topic, teamwork, time management and work organization.

## ACTIVITY 2: P2 - FAN

**Hours:** 2h  
Practical classes: 2h

**Description:**  
The objective of this lab is to characterize a fan by calculating the characteristic curves: Ptot-Q, Nabs-Q and Ψv-Q.

**Support materials:**  
Lab guides and reports manual, instrumentation and laboratory equipment. Extra material can be uploaded in ATENEA

**Descriptions of the assignments due and their relation to the assessment:**  
Deliverable activity by writing the corresponding practice report to be evaluated. The evaluation mark is within the percentage of labs in the grade system of the course.

**Specific objectives:**  
Acquiring the ability to know, understand and apply the knowledge of the basic principles related to the topic, teamwork, time management and work organization.

## ACTIVITY 3: P3 - CONTROL VALVE

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

**Description:**  
This practice aims to study a control valve. It is intended to obtain (i) the ratio Kv (flow coefficient/factor), (ii) the inherent curve and (iii) installed curve.

**Support materials:**  
Lab guides and reports manual, instrumentation and laboratory equipment. Extra material can be uploaded in ATENEA

**Descriptions of the assignments due and their relation to the assessment:**  
Deliverable activity by writing the corresponding practice report to be evaluated. The evaluation mark is within the percentage of labs in the grade system of the course.
### Specific objectives:
Acquiring the ability to know, understand and apply the knowledge of the basic principles related to the topic, teamwork, time management and work organization.

### ACTIVITY 4: P4 - WATER HAMMER

<table>
<thead>
<tr>
<th>Hours</th>
<th>Practical classes: 2h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description:</td>
<td>This laboratory session aims to introduce students to techniques of control, measurement, study and prevention of water hammer.</td>
</tr>
<tr>
<td>Support materials:</td>
<td>Lab guides and reports manual, instrumentation and laboratory equipment. Extra material can be uploaded in ATENEA</td>
</tr>
<tr>
<td>Descriptions of the assignments due and their relation to the assessment:</td>
<td>Deliverable activity by writing the corresponding practice report to be evaluated. The evaluation mark is within the percentage of labs in the grade system of the course.</td>
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</table>

### ACTIVITY 5: P5 - MORPHOLOGY OF POSITIVE DISPLACEMENT PUMPS

<table>
<thead>
<tr>
<th>Hours</th>
<th>Laboratory classes: 1h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description:</td>
<td>The aim of this laboratory session is to get familiar with the morphology of volumetric positive displacement pumps, identify and describe them, components and key features.</td>
</tr>
<tr>
<td>Support materials:</td>
<td>Lab guides and reports manual, instrumentation and laboratory equipment. Extra material can be uploaded in ATENEA</td>
</tr>
<tr>
<td>Descriptions of the assignments due and their relation to the assessment:</td>
<td>Deliverable activity by writing the corresponding practice report to be evaluated. The evaluation mark is within the percentage of labs in the grade system of the course.</td>
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### ACTIVITY 6: P6 - MORPHOLOGY OF VALVES

<table>
<thead>
<tr>
<th>Hours</th>
<th>Laboratory classes: 2h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description:</td>
<td>The aim of this laboratory session is to get familiar with the morphology of hydraulic valves, identify and describe them, components and key features.</td>
</tr>
<tr>
<td>Support materials:</td>
<td>Lab guides and reports manual, instrumentation and laboratory equipment. Extra material can be uploaded in ATENEA</td>
</tr>
</tbody>
</table>
**ACTIVITY 7: P7 - CIRCUIT ASSEMBLY**

**Description:**
The aim of this laboratory session is to assemble hydraulic circuits in a basic didactic panel, manipulate the elements and analyse their performance.

**Support materials:**
Lab guides and reports manual, instrumentation and laboratory equipment. Extra material can be uploaded in ATENEA

**Details of the assignments due and their relation to the assessment:**
Deliverable activity by writing the corresponding practice report to be evaluated. The evaluation mark is within the percentage of labs in the grade system of the course.

**Specific objectives:**
Acquiring the ability to know, understand and apply knowledge of the basic principles related to the topic, teamwork, time management and work organization.

<table>
<thead>
<tr>
<th>Hours: 2h</th>
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<tbody>
<tr>
<td>Laboratory classes: 2h</td>
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<table>
<thead>
<tr>
<th>ACTIVITY 8: CP - LABMULTIPLE-CHOICE TEST</th>
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</table>

**Description:**
The aim of this session is to assess the knowledge and progress in the lab sessions.

**Support materials:**
Formula sheet done by the students themselves on one side of A4 paper.

**Details of the assignments due and their relation to the assessment:**
Activity assessable where the note is within the rating system of the subject.

**Specific objectives:**
Acquiring the ability to know, understand and apply knowledge of the basic principles of the modules/topics, individual or team work and time management.

<table>
<thead>
<tr>
<th>Hours: 2h</th>
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<tbody>
<tr>
<td>Laboratory classes: 2h</td>
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<table>
<thead>
<tr>
<th>ACTIVITY 9: C - MULTIPLE-CHOICE TEST</th>
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</table>

**Description:**
The aim of this session is to assess the knowledge and progress in the lecture sessions.

**Support materials:**
Formula sheet done by the students themselves on one side of A4 paper.
## Activity 10: E - Application Exercises

<table>
<thead>
<tr>
<th>Description:</th>
</tr>
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<tbody>
<tr>
<td>Exercises, reading articles, reading books chapter, attending seminars and / or conferences, etc. proposed by the teacher.</td>
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<table>
<thead>
<tr>
<th>Support materials:</th>
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<tbody>
<tr>
<td>Activity assessable where the note is within the rating system of the subject.</td>
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<table>
<thead>
<tr>
<th>Descriptions of the assignments due and their relation to the assessment:</th>
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</thead>
<tbody>
<tr>
<td>Deliverable activity. Some of the exercises will have mark and other exercises will be self-assessed. The part to note is placed within the corresponding percentage of the rating system of the subject.</td>
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<table>
<thead>
<tr>
<th>Specific objectives:</th>
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<tbody>
<tr>
<td>Promote the work with the contents and main topics of the subject.</td>
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### Hours: 6h
- **Self study:** 6h

## Activity 11: EX1 - First Mid-Semester

<table>
<thead>
<tr>
<th>Description:</th>
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<tbody>
<tr>
<td>Individual partial test.</td>
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<table>
<thead>
<tr>
<th>Support materials:</th>
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</thead>
<tbody>
<tr>
<td>Formula sheet done by the students themselves on one side of A4 paper.</td>
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<table>
<thead>
<tr>
<th>Descriptions of the assignments due and their relation to the assessment:</th>
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<tbody>
<tr>
<td>The test is 33% of the final grade and will be done on the scheduled date and time.</td>
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## Activity 12: EX2 - Second Mid-Semester

<table>
<thead>
<tr>
<th>Description:</th>
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<tr>
<td>Individual partial test.</td>
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<table>
<thead>
<tr>
<th>Support materials:</th>
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<tbody>
<tr>
<td>Formula sheet done by the students themselves on one side of A4 paper.</td>
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</table>

<table>
<thead>
<tr>
<th>Descriptions of the assignments due and their relation to the assessment:</th>
</tr>
</thead>
<tbody>
<tr>
<td>The test is 33% of the final grade and will be done on the scheduled date and time.</td>
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</tbody>
</table>
ACTIVITY 13: AC - AUTOMULTIPLE-CHOICE TEST

Description:
Evaluable autotests to make as individual self-learning.

Support materials:
Questionnaires in ATENEA by WIRIS

Descriptions of the assignments due and their relation to the assessment:
Activity assessable where the note is within of the rating system of the subject.

Specific objectives:
Acquiring the ability to know, understand and apply knowledge of the basic principles of the modules / topics, individual work and time management.

Qualification system

- First mid-semester examination: 35%
- Second mid-semester examination: 35%
- Multiple-choice tests (during theory or problem sessions): 15%
- Laboratory practicals: 10% (Laboratory 5% + LabMultiple-choice tests 5%)
- AutoMultiple-choice tests (virtual questionaries) 2.5%
- Applied exercises (problems, reading assignments such as articles or book chapters, attendance of seminars and/or lectures, etc.): 2.5%

*The unsatisfactory result of the examination of the first mid-term, may be re-conducted by a written exam to be carried out on the day (official date and time) of the final examen of the subject. Only students with a grade lower than 5 of the evaluation act could take this examination. The mark of the exam is between 0 and 10. The mark obtained in this examination will be averaged with the grade obtained in the first act of evaluation and will replace the mark of the first act of evaluation unless it is lower.

For those students who meet the requirements and submit to the reevaluation examination, the grade of the reevaluation exam will replace the grades of all the on-site written evaluation acts (tests, midterm and final exams) and the grades obtained during the course for lab practices, works, projects and presentations will be kept.

If the final grade after reevaluation is lower than 5.0, it will replace the initial one only if it is higher. If the final grade after reevaluation is greater or equal to 5.0, the final grade of the subject will be pass 5.0.

Regulations for carrying out activities

The test sessions will consist of a multiple choice paper, which will last approximately 30 minutes. Students will mark them in pairs.

Students will work in groups of three on problems that must be handed in. They may be asked to explain their results in applied sessions.
Bibliography

Basic:

- Codina, E.; Heras, S. de la. Monografíes sobre components i sistemes oleohidràulics. Departament de Mecànica de Fluids.

Complementary:

- De las Heras, S. Màquines hidràuliques. Reprografía ETSEIAT.
Others resources:

http://www.gerolab.es/