



Universitat de Lleida

DEGREE CURRICULUM  
**THERMAL ENGINEERING II**

Coordination: MARTORELL BOADA, INGRID

Academic year 2017-18

## Subject's general information

<b>Subject name</b>	THERMAL ENGINEERING II			
<b>Code</b>	102301			
<b>Semester</b>	1st Q(SEMESTER) CONTINUED EVALUATION			
<b>Typology</b>	Degree	Course	Typology	Modality
	Bachelor's Degree in Mechanical Engineering	3	COMPULSORY	Attendance-based
<b>ECTS credits</b>	6			
<b>Groups</b>	1GG,2GM,5GP			
<b>Theoretical credits</b>	3			
<b>Practical credits</b>	7.2			
<b>Coordination</b>	MARTORELL BOADA, INGRID			
<b>Department</b>	INFORMATICA I ENGINYERIA INDUSTRIAL			
<b>Teaching load distribution between lectures and independent student work</b>	60 h lectures (40%) 90 h autonomous work (60%)			
<b>Important information on data processing</b>	Consult <a href="#">this link</a> for more information.			
<b>Language</b>	Catalan 100%			
<b>Distribution of credits</b>	Dr. Ingrid Martorell Boada 6,8 ECTS Dr. Marc Medrano 3,4 ECTS			
<b>Office and hour of attention</b>	Set up with the teacher			

Teaching staff	E-mail addresses	Credits taught by teacher	Office and hour of attention
MARTORELL BOADA, INGRID	imartore@diei.udl.cat	6,8	
MEDRANO MARTORELL, MARCO	mmedrano@diei.udl.cat	3,4	

## Subject's extra information

Thermal Engineering II is a compulsory subject taught in third course during the first semester in the Bachelor of Mechanical Engineering.

This course requires continuous work throughout the semester in order to achieve the goals. It is recommended to visit frequently the Virtual Campus, where course information is announced. We recommend using direct mail instead of the teacher's personal email in the Messaging Virtual Campus.

The course is a journey through the different principles of thermodynamics and refrigeration and power cycles are also covered.

It is **COMPULSORY** that the students bring the following elements of individual protection (EPI) to the practices at the laboratory.

- Blue laboratory gown from UdL (unisex)
- Protection glasses
- Mechanical protection gloves

They can be purchased through the shop Údels of the UdL:

C/ Jaume II, 67 baixos  
Centre the Cultures i Cooperació Transfronterera

<http://www.publicacions.udl.cat/>

The use of other elements of protection (for example caps, masks, gloves of chemical or electrical risk, etc.) will depend on the type of practice to be done. In that case, the teacher will inform of the necessity of specific EPI.

Not bringing the EPI's described or not fulfilling the norms of general security that are detailed below imply that the student can not access to the laboratories or have to go out of them. The no realisation of the practices for this reason imply the **consequences in the evaluation** of the subject that are described in this course guide.

### GENERAL NORMS OF SECURITY IN LABORATORY PRACTICES

- Keep the place of realisation of the practices clean and tidy. The table of work has to be free from backpacks, folders, coats...
- No short trousers or short skirts are allowed in the laboratory.

- Closed and covered footwear is compulsory in the laboratory.
- Long hair needs to be tied.
- Keep the laboratory gown laced in order to be protected from spills of chemicals.
- Bangles, pendants or wide sleeves are not allowed as they can be trapped.
- Avoid the use of contact lenses, since the effect of the chemical products is much bigger if they enter between the contact lense and the cornea. Protection over-glasses can be purchased.
- No food or drink is allowed in the laboratory.
- It is forbidden to smoke in the laboratories.
- Wash your hands whenever you have contact with a chemical product and before going out of the laboratory.
- Follow the instructions of the teacher and of the laboratory technicians and ask for any doubt on security.

For further information, you can check the following document of the *Servei de Prevenció de Riscos Laborals de la UdL*: <http://www.sprl.udl.cat/alumnes/index.html>

## Learning objectives

- Obtain the necessary data of physical properties of fluids in tables and diagrams with solvency.
- Be able to numerically solve the problems of thermodynamics.
- Be able to argue the results with critical thinking
- Be able to critically analyze and synthesize concepts learned in the course
- Learn the theoretical and practical knowledge of thermal energy.
- Understand the basic principles of power and cooling cycles.

## Competences

### Cross-disciplinary competences

- **EPS1.** Capacity to solve problems and prepare and defence arguments inside the area of studies.
- **EPS6.** Capacity of analysis and synthesis

### Specific competences

- **GEM21.** Applied knowledge of thermal engineering.
- **GEM24.** Applied knowledge of the basics of fluidomechanic machinery.

## Subject contents

### 1. Properties of pure substances

- 1.1. Pure substances
- 1.2. Phases of a pure substance
- 1.3. Change processes do a pure substance
- 1.4. Property diagrams for phase change processes
- 1.5. Property tables
- 1.6. Ideal gas equation of state
- 1.7. The compressibility factor - a measure of the deviation from ideal gas
- 1.8. Specific heat

- 1.9. Internal energy, enthalpy and specific heat of ideal gases
- 1.10. Internal energy, enthalpy and specific heat of solids and liquids
- 1.11. Problem properties pure substances

## **2. First law of thermodynamics**

- 2.1. The first principle of thermodynamics
- 2.2. Energy balance for closed systems
- 2.3. Energy balance for steady state systems
- 2.4. Some stationary equipment engineering
- 2.5. Energy balance for non-steady state processes
- 2.6. Problems first principle of thermodynamics

## **3. Second law of thermodynamics**

- 3.1. Introduction to the second law of thermodynamics
- 3.2. Thermal energy storage
- 3.3. Heat engines
- 3.4. Efficiencies in energy conversion
- 3.5. Refrigerators and heat pumps
- 3.6. The Carnot cycle
- 3.7. The Carnot heat engine
- 3.8. The refrigerator and heat pump Carnot
- 3.9. Problems of the second law of thermodynamics

## **4. Entropy**

- 4.1. Entropy
- 4.2. The principle of entropy increase
- 4.3. Entropy change of pure substances
- 4.4. Isentropic processes
- 4.5. Entropy change of liquids and solids
- 4.6. Entropy change of ideal gases
- 4.7. Isentropic efficiency of steady state devices

4.8. Balance of entropy

4.9. Problems entropy

## 5. Gas power cycles

5.1. Considerations basic analysis of power cycles

5.2. Carnot cycle and its value engineering

5.3. Standard air assumptions

5.4. Reciprocal motor

5.5. The Otto cycle: the ideal cycle for spark-ignition engines

5.6. Diesel Cycle: The Ideal Cycle for Compression-ignition engines

5.7. Stirling and Ericsson cycles

5.8. Brayton cycle: the ideal cycle for gas turbines

5.9. Problems cycle gas power

## 6. Steam power cycles and combined cycles

6.1. Carnot cycle steam

6.2. The Rankine cycle: the ideal cycle steam power cycles

6.3. Deviations of actual vapor power cycles ideals

## Methodology

The methodology of the course will be divided into:

- 1.-Lectures where the teacher will present the theory necessary for the acquisition of knowledge.
- 2.-Problems sessions where teacher will present some examples but basically students will play an active role in the learning process working in small groups or individually.
- 3.-Practical laboratory sessions where students work in group.

## Development plan

Week	Methodology	Topic	Lecture Hours	Autonomous work hours
1-2	Lecture. Resolution of problems	Subject presentation and 1. Properties of pure substances, .	6	9
2-4	Lecture. Resolution of problems	2. First law of thermodynamics	8	12

4-6	Lecture. Resolution of problems.	3. Second law of thermodynamics	8	12
6-8	Lecture. Resolution of problems.	4. Entropy	10	15
9		Evaluation. Written test.		
10-12	Lecture. Resolution of problems.	5. Gas power cycles	12	18
13-15	Lecture. Resolution of problems. Lab practices	6. Steam power cycles and combined cycles	12	18
16-19		Evaluation. Written Test. Recovery		

## Evaluation

### EVALUATION ACTIVITY 1: FIRST PARTIAL

-35%

-Score  $\geq 3$  to average with the other scores of the course

### EVALUATION ACTIVITY 2: SECOND PARTIAL

-35%

-Score  $\geq 3$  to average with the other scores of the course.

### EVALUATION ACTIVITY 3: LAB ACTIVITIES- In group activities

-20%

-iN GROUP

-Score  $\geq 4$  (all practices average)

### EVALUATION ACTIVITY 4: Problems and activities in class- during the course, in groups

-10%

## Bibliography

### Recommended references

- Yunus A. Çengel, Michael A. Boles "Thermodynamics, an engineering approach", International Edition, Fourth Edition, Mc Graw Hill, ISBN: 0-07-238332-1.
- Michael J. Moran, Howard N. Shapiro, Daisie D. Boettner, Margaret B. Bailey. "Fundamentals of Engineering Thermodynamics", 7th Edition, ISBN-10: 0470917687
- P. Chattopadhyay, "Engineering Thermodynamics, 2on Edition, ISBN-10: 0199456151
- Michael Horsley, M. Horsley, "Engineering Thermodynamics", Springer, ISBN-10: 0412445204.