Universitat de Lleida

DEGREE CURRICULUM

THERMODYNAMICS AND HEAT TRANSMISSION

Coordination: CANTERO GÓMEZ, M. ROSA

Academic year 2019-20

THERMODYNAMICS AND HEAT TRANSMISSION 2019-20

Subject's general information

Subject name	THERMODYNAMICS AND HEAT TRANSMISSION
Code	102331
Semester	1st Q(SEMESTER) CONTINUED EVALUATION
Typology	

Degree	Course	Character	Modality
Not informed	2	COMPULSORY	Attendance-based
Bachelor's degree in Industrial Organization and Logistics Engineering	2	COMPULSORY	Attendance-based

Course number of credits (ECTS)	6
Type of activity, credits, and groups	

Activity type	PRALAB	PRAULA	TEORIA
Number of credits	1	2	3
Number of groups	3	2	2

Coordination	CANTERO GÓMEZ, M. ROSA
Department	COMPUTER SCIENCE AND INDUSTRIAL ENGINEERING
Teaching load distribution between lectures and independent student work	60 h lectures (40 %) 90 h Autonomous work (60 %)
Important information on data processing	Consult this link for more information.
Language	Catalan
Distribution of credits	3 theoretical credits 3 practical credits

Teaching staff	E-mail addresses	Credits taught by teacher	Office and hour of attention
CANTERO GÓMEZ, M. ROSA	rosa.cantero@udl.cat	13	

Subject's extra information

Continuous work is required throughout the semester in order to achieve the objectives of this subject. It is highly recommended that students visit the Virtual Campus associated with the subject on a frequent basis.

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

- Laboratory gown from UdL
- 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/

There will be a specific service for the *Campus Universitari d'Igualada*.

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 laboratoy 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

- Capacity to understand thermodynamics and its principles.
- Capacity to understand the different mechanisms of heat transmission.
- Capacity to understand the power and refrigeration cycles.
- Capacity to understand the concepts of psychrometry.
- Capacity to critically analyze and synthesize the knowledge acquired.
- Capacity to obtain data of fluid properties from tables and diagrams with solvency.
- Capacity to use the knowledge acquired to solve engineering problems related to thermodynamics and heat transmission.
- Capacity to reason and analyze the results obtained from the problems worked on, thus deepening critical thinking.

Competences

Basic competences

- **B01.** That students have demonstrated to possess and understand knowledge in an area of study that starts from the base of general secondary education, and is usually found at a level that, although supported by advanced textbooks, also includes some aspects that imply knowledge coming from the vanguard of his/her field of study.
- **B02.** That students know how to apply their knowledge to their work or vocation in a professional manner and possess the skills that are usually demonstrated through the elaboration and defense of arguments and the resolution of problems within their area of study.
- **B04.** That students can transmit information, ideas, problems and solutions to a specialized and non-specialized public.

General competences

- **CG3.** To synthesize basic and technological subjects, which enable them to learn new methods and theories, and provide them with versatility to adapt to new situations.
- **CG4.** To solve problems with initiative, make decisions, creativity, critical reasoning and to communicate and transmit knowledge, skills and abilities in the field of Industrial Chemical Engineering.
- **CG6.** To implement specifications, regulations and mandatory rules.
- **CG10.** To work in a multilingual and multidisciplinary environment.

Specific competences

- **CE2.** To conceptualize and command the fundamental concepts about the general laws of mechanics, thermodynamics, fields and waves and electromagnetism and their application to solve problems in engineering.
- **CE7**. To conceptualize applied thermodynamics and heat transmission. To recognize the basic principles and their application to solving engineering problems.

Transversal competences

- **CT1.** To develop a proper understanding and oral and written expression of Catalan and Spanish.
- **CT3.** To implement new technologies and technologies of information and communication.
- **CT5.** To apply essential notions of scientific thinking.

Subject contents

1. Properties of gases

1.1. PVT behavior of ideal gases

1.2. Ideal gas mixtures

1.3. Non-ideal behavior of gases

1.4. The Virial equation of state

1.5. Condensation of gases

1.6. Critical point

1.7. Van der Waals equation of state

1.8. Law of corresponding states

2. Phase equilibrium

2.1. Phase rule

2.2. Diagrams P-T: one-component phase equilibrium

2.3. Clausius-Clapeyron equation

3. Heat transfer

3.1. Conduction

3.1.1. Thermal conductivity

3.1.2. Steady heat conduction

3.2. Convection

3.2.1. Forced convection

3.2.2. Natural convection

3.3. Radiation

3.3.1.Thermal radiation

3.3.2. Blackbody radiation

3.3.3. Radiation properties

4. First law of thermodynamics

4.1 Work

4.2. First law of thermodynamics

4.3. Enthalpy

4.4. Specific heat

4.5. Calculation of magnitudes included in the first law of thermodynamics

5. Second and third laws of thermodynamics

5.1. Heat engines, heat pumps and refrigerators

5.2. Enunciates of the second law of thermodynamics

5.3. Carnot machine

5.4. Carnot efficiency

5.5 Entropy

5.6. Entropy change for an ideal gas

5.7. Entropy change for vapors, solids and liquids

5.8. The inequality of Clausius

5.9. Entropy change for an irreversible process

5.10. Entropy and third law of thermodynamics

6. Vapor power and refrigeration cycles

6.1. Rankine cycle

6.2. Rankine cycle efficiency

6.3. Reheat cycle

6.4. Regenerative cycles

6.5. Losses on power cycle efficiency

6.6. Vapor refrigeration cycle

6.7. Heat pump

7. Gas power and refrigeration cycles

7.1. Air standard cycle

7.2. Otto cycle

7.3. Diesel cycle

7.4. Brayton cycle

7.5. Regenerative Brayton cycle

7.6. Gas refrigeration cycle

8. Psychrometry

8.1. Mixture of water vapor and dry air

8.2. Adiabatic saturation

8.3. Wet bulb temperature

8.4. Psychometric diagram

8.5. Air conditioning processes

Methodology

- Lectures in which the theoretical concepts of each topic are introduced, illustrating them with examples.
- Problem-solving sessions in which students take an active part in their learning process working in small groups or individually.
- Work of a practical case in small groups.

Development plan

Week	Methodology	Contents	Lecture hours	Autonomous work hours
1-2	Lecture. Problem solving.	Presentation subject. 1. Properties of gases.	6	9
2-3	Lecture. Problem solving.	2. Phase equilibrium	4	6
3-6	Lecture. Problem solving.	3. Heat transfer. Presentation case study.	11	15
6-7	Lecture. Problem solving.	4. First law of thermodynamics	4	8
7-8	Lecture.Problem solving. Practical case.	5. Second and third laws of thermodynamics. Work practical case.	7	12
9		Evaluation. Written test.		
10-12	Lecture. Problem solving. Practical case.	6. Vapor power and refrigeration cycles. Work practical case.	9	15
12-14	Lecture.Problem solving. Practical case.	7. Gas power and refrigeration cycles. Work practical case.	9	15
14-15	Lecture.Problem solving. Practical case.	8. Psychrometry. Work practical case.	6	10
16-19		Evaluation. Written test. Referral exam.		

Evaluation

- **Assessment activity 1 (AA1)**: Written test, units 1-5 (20% of the final qualification).
- **Assessment activity 2 (AA2)**: Written test, units 1-8 (50% of the final qualification). In case that the result of AA2 is higher than that of AA1, the result of AA1 will be improved and equalled to AA2 when applying the designated percentages.

- **Assessment activity 3**: Individual controls of the problems worked on in group and active participation in the work sessions (15% of the final qualification).
- **Assessment activity 4**: Work in the practical case (15% of the final qualification).

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Referral exam: Units 1-8. Allows students to obtain up to 70% of the final qualification (equivalent to AA1 + AA2).

Bibliography

- Michael J. Moran, Howard N. Shapiro, Daisie D. Boettner, Margaret B. Bailey. “Fundamentals of Engineering Thermodynamics”, 7th Edition, Wiley, 2010. ISBN-10: 0470917687.
- Potter, Merle C., Scott, Elaine P., Termodinámica. Thomson, 2006. ISBN: 9789706865656.
- Yunus A. Çengel, Michael A. Boles, "Thermodynamics, an engineering approach", 4th Edition, McGraw-Hill, 2001. ISBN: 0-07-238332-1.
- Y. A. Çengel, “Heat Transfer. A practical approach”, McGraw-Hill, 1998. ISBN: 0-07-011505-2.