COURSE DATA

Data Subject	
Code	34923
Name	Applied thermodynamics and heat transfer
Cycle	Grade
ECTS Credits	6.0
Academic year	2022 - 2023

Study (s)

Degree	Center	Acad. year	Period
1404 - Degree in Industrial Electronic Engineering	School of Engineering	2	Second term

Subject-matter

Degree	Subject-matter	Character
1404 - Degree in Industrial Electronic Engineering	8 - Applied thermodynamics and heat transfer	Obligatory

Coordination

Name	Department
IZQUIERDO SANCHIS, MARTA	245 - Chemical Engineering
SANCHEZ TOVAR, RITA	245 - Chemical Engineering

SUMMARY

The course ***Applied Thermodynamics and Heat Transfer*** is a compulsory course taught in the second year of the degree in Industrial Electronic Engineering in the second (spring) semester. In the curriculum of the University of Valencia has a total of 6 ECTS.

Thermodynamics is a fundamental science that studies the energy, and, since a long time, it is an essential worldwide part of engineering curricula. The purpose of this subject is to provide students with an introductory treatment of Thermodynamics from the engineering point of view. This science has a universal applicability, as evidence by the fact of being used in different areas such as Physics, Chemistry and Engineering; in fact, the thermodynamic principles are the same, but their applications differ. The basic applications from the engineering point of view are determination of the needs of heat and work in the physical and chemical processes, distinguishing two major application areas, power generation and refrigeration.

This subject aims to provide students the ability to design and manage the operation of thermal systems of industrial plants. For this purpose, in this subject is studied the basic knowledge of estimated properties of pure substances, it is treated the actual processes of typical energy transformation of the industry (heat generation process, air conditioning, gas, steam and refrigeration power cycles, among others), and finally, it is analyzed the physical fundamentals of the different forms of heat transfer.

The contents of the subject are**: Basics of applied thermodynamics. Heat transfer mechanisms. Basic principles of thermotechnology. Furnaces and boilers. Heat engines. Refrigeration circuits and systems.**

The theory classes will be taught in Spanish and practical classes as stated in the course information available on the website of the degree.

PREVIOUS KNOWLEDGE

Relationship to other subjects of the same degree

There are no specified enrollment restrictions with other subjects of the curriculum.

Other requirements

The background needed for this subject is basic knowledge of physics, mathematics and chemistry, as well as basic level of English reading.

OUTCOMES

1404 - Degree in Industrial Electronic Engineering

- CG3 - Knowledge of basic and technological subjects that allows students to learn new methods and theories and provides them with versatility to adapt to new situations.
- CG4 - Ability to solve problems with initiative, decision-making skills, creativity and critical reasoning and to communicate and transmit knowledge, abilities and skills in the field of industrial engineering (with specific industrial electronics technology).
- CG6 - Ability to deal with specifications, regulations and mandatory standards.
- CG9 - Ability to organise and plan work in companies and in other institutions and organisations.
- CG11 - Knowledge, understanding and ability to apply the necessary legislation for practising professionally as a qualified industrial engineer.
- CG18 - Knowledge of applied thermodynamics and heat transfer. Basic principles and their application to solve engineering problems.

LEARNING OUTCOMES

Learning results

- Apply the mass and energy conservation principles to the heat transfer operations. (Outcomes G3, G4, R1)
- Know the heat transfer mechanisms: conduction, convection and radiation. (Outcomes G3, G4, R1)
- Identify and distinguish the mechanisms that happen in different heat transfer problems. (Outcomes G3, G4, R1)
- Know how locate in the literature and estimate the physical and thermodynamic values required for the analysis and design of heat transfer operations. (Outcomes G3, G4, G6, R1)
- Apply the mathematical models that describe the heat transfer phenomena. (Outcomes G3, G4, R1)
- Apply the thermodynamic principles to solve heat transfer problems. (Outcomes G3, G4, R1)
- Apply, judiciously, an appropriate state equation to represent the PVT behavior of gases at high pressure and/or liquids. (Outcomes G3, G4, R1)
- Apply the thermodynamic principles to power and refrigeration cycles. (Outcomes G3, G4, R1)
- Know the types and characteristics of the industrial furnaces and boilers. (Outcomes G3, G6, G11)
- Know the operation principles, types and properties of the heat engines and refrigeration systems. (Outcomes G3, G6, G11,R1)
- Know the types and characteristics of equipment used in power and refrigeration cycles. (Outcomes G3, G6, G11, R1)
- Apply the thermodynamic principles to combustion processes. (Outcomes G3, G4, G6, G11, R1)
- Know and be able to select and size the heat transfer equipment and systems used. (Outcomes G3, G4, G6, G11, R1)
- Know and be able to select and size the air conditioning and refrigeration systems. (Outcomes G3, G4, G6, G11, R1)

Skills to be acquired

Students will be able to:

- Calculate the heat and work required of different processes for closed systems, or steady-state flow, make up of pure substances.
- Distinguish between reversible and irreversible processes and apply the efficiency concept for the calculation of work in irreversible processes.
- Calculate the entropy of different processes using the Second Law.
- Define the concept of heat engines.
- Interpret the different types of thermodynamic diagrams of pure substances.
- Use the Thermodynamic Property Tables of pure water to calculate any thermodynamic property variations in different processes.
- Quantify the PVT behavior of pure substances using equations of state.
- List the different variables involved in a combustion process.
- Calculate the composition and temperature of the combustion gases.
- Understand the thermodynamic fundamentals of heat engines used in power cycles.
- Design, thermodynamically, the devices used for power generation.
- Calculate the thermal efficiency in steam and gas turbines.
- Apply the thermodynamic principles to refrigeration cycles.

- Know the different mechanisms of heat transfer and its rate equations.
- Solve the equations of heat transport by conduction and apply for determining the temperature distribution in a material and for calculating the thickness of insulation.
- Solve the equations of heat transport by convection and apply it to the determination of temperature variations and heat flows.
- Determine the heat transfer by radiation in different ways and in combination with other energy transport mechanisms.
- Know the industrial equipment base mainly on radiation: boilers and furnaces.

In addition to the specific objectives mentioned above, the course will encourage the development of several **social and technical skills**, among which include:

- Capacity for analysis and synthesis.
- Ability to interpret relevant data.
- Ability to communicate ideas, problems and solutions.
- Ability to argue from rational and logical criteria.
- Ability to speak properly and organized.
- Ability to develop a problem in a systematic way and organized.
- Ability to critically analyze the results of a problem.
- Ability to work independently.
- Ability to integrate and actively participate in group tasks.
- Ability to properly distribute the time to develop individual and group tasks.

DESCRIPTION OF CONTENTS

1. INTRODUCTION

Thermodynamic state and its surroundings. Internal energy. The first law of thermodynamics. State function. Enthalpy. The steady-state steady-flow process. The reversible process. The second law of thermodynamics. Entropy. Heat engines.

2. VOLUMETRIC BEHAVIOUR (or PVT) OF PURE SUSBSTANCES

PVT diagrams and properties tables. Equations of state. Generalized correlations for gases and liquids.

3. THERMODYNAMICS OF STEAM

Liquid and vapour saturated. Superheated steam. Thermodynamic diagrams. Thermodynamic tables.

4. COMBUSTION

Fuels. Energy and mass balances in the combustion process. Adiabatic flame temperature.

5. VAPOR POWER CYCLES

Thermal power plant performance. Carnot cycle. Rankine cycle. Cogeneration systems.

6. GAS POWER CYCLES

Internal combustion engines. Otto cycle. Diesel cycle. Gas turbines. Brayton cycle. Other power cycles.

7. REFRIGERATION CYCLES

Vapor-compression refrigeration systems. Class of refrigerants. Cascade vapor-compression refrigeration systems. Gas refrigeration systems. Reversed Brayton cycle. Absorption refrigeration. Circuits and industrial refrigeration systems.

8. HEAT TRANSFER BY CONDUCTION AND CONVECTION

Heat transfer mechanism. Rate equation in molecular heat transport: Fourier´s law. Heat conduction in solids. Heat conduction through composite walls. Rate equation in turbulent flow: individual coefficient. Heat flow between phases: overall heat transfer coefficient.

9. RADIATION

Fundamental equation of radiation. Radiation Exchange between surfaces. Individual heat transfer coefficient by radiation. Radiation in the presence of other mechanisms of heat transfer. Furnaces and boilers.

WORKLOAD

ACTIVITY	Hours	% To be attended
Theory classes	35,00	100
Classroom practices	25,00	100
Development of individual work	20,00	0
Preparation of evaluation activities	25,00	0
Preparing lectures	25,00	0
Preparation of practical classes and problem	20,00	0
TOTAL	**150,00**	

TEACHING METHODOLOGY

The development of the course is structured in lectures on the theory together with the resolution of related problems, and carrying out works.

In the lectures, master classes will be the basic methodology. The professor will present by means of presentation and/or explanation of the contents highlighting those key aspects for understands them. The main competences worked on by these activities will be G3, G4, G6, G11 and R1.

Practical sessions of problems will be developed following two models. Some of the classes will be the professor who solves a series of sample problems in order to help the students to identify the essential

elements of the way the problem is set out and its solution. In other practical sessions will be the students, individually or in team, who should solve similar problems under the supervision of the professor. After the work, the problems will be collected, analyzed and corrected by the professor. The main competences worked on by these activities will be G3, G4, G6, G11 and R1.

The proposed work to the student will be divided into two types: complete Problems, with a similar complexity to the problem exams, and Tests, designed to prepare the most important concepts of each unit. At the end of the lectures, a test will be made, and the problems will have a timetable for its completion and delivery by the students. After its correction, the students will be informed of their results. The main competences worked with these activities will be G3, G4, G6, G11 and R1.

EVALUATION

The assessment of student learning will be carried out using two models:

Model A: The assessment with this model is based on a continuous assessment taking account the works (tests and proposed problems) and two objective exams according to two parts (Part I: units 1 to 4 and Part II: units 5 to 9). The exam of Part I will be at the end of the Part I, and the exam of Part II will be on the official date of the first call.

The final mark will be calculated as the greater one of:

- the weighting between the average mark of the tests (20%), delivered problems (15%) and the grade of the two objective exams (65%),or
- the grade of the two objective exams plus a 5% of the average mark of the works (tests and proposed problems)

If a minimum mark of 4 (out of 10) is not gotten in the average score of the tests, the final mark will be the average of the two objectives tests.

On the second call the evaluation will be conducted by Model B.

Model B: The assessment of the course with this model will be realized through an exam of all contents of the course in the official date.

The final mark with this model will be obtained as the greater one of:

- the weighting between the average mark of activities (20%) and the mark of the exam (80%), or
- the mark of the exam

If a minimum mark of 4 (out of 10) is not gotten in the exam, the final mark will be the grade obtained in the exam.

The exams will have theoretical and practical questions and problems. Achievement of competences G3, G4, G6 and R1 will be evaluated.

The subject will be passed when the average final mark is equal or greater than 5 (out of 10).

Anyhow, the evaluation system will be based on the guides stated in the “Reglament d’Avaluació i

Qualificació de la Universitat de València per a Graus i Màsters” (ACGUV 108/2017).

REFERENCES

Basic

- SMITH, Joe M., VAN NESS, Hendrick C. y ABBOTT, Michael M., 2014, Introducción a la Termodinámica en ingeniería Química (séptima edición). McGraw-Hill Interamericana (http://links.uv.es/A3RmkY0)
- ÇENGEL, Yunus A. y BOLES, Michael A., 2012, Termodinámica (séptima edición). McGraw-Hill Interamericana (http://links.uv.es/t1BJ24x)
- MORAN, Michael J. y SHAPIRO, Howard N., 2004, Fundamentos de Termodinámica Técnica, 2ª ed (4ª original), Reverté, Barcelona.
- SANCHOTELLO, Margarita y ORCHILLÉS, Antoni V., 2007, Transmissió de calor, 1ª ed., PUV, Valencia

- HOLMAN, Jack P., 2000, Transferencia de calor, 1ª ed. Español, McGraw-Hill, Madrid

Additional

- DE LUCAS, Antonio, 2004, Termotecnia Básica para Ingenieros Químicos: Bases de Termodinámica Aplicada, Universidad de Castilla-La Mancha.
- DE LUCAS, Antonio, 2004, Termotecnia Básica para Ingenieros Químicos: Procesos Termodinámicos y Máquinas, Universidad de Castilla-La Mancha.
https://links.uv.es/tRue6Az)
- POLING, Bruce E., PRAUSNITZ, John M., O'CONNELL, John P., 2001, The properties of gases and liquids. McGraw-Hill, New York.
- YAWS, Carl L., 2014, Thermophysical Properties of Chemicals and Hydrocarbons (Second Edition), Elsevier Science, Amsterdam.
(http://www.sciencedirect.com/science/book/9780323286596)