Course guide
340038 - FENT-F - Fundamentals of Thermal Engineering

Last modified: 19/05/2026

Unit in charge:	Vilanova i la Geltrú School of Engineering
Teaching unit:	729 - MF - Department of Fluid Mechanics.
Degree:	BACHELOR'S DEGREE IN ELECTRICAL ENGINEERING (Syllabus 2009). (Compulsory subject). BACHELOR'S DEGREE IN INDUSTRIAL DESIGN AND PRODUCT DEVELOPMENT ENGINEERING (Syllabus 2009). (Optional subject). BACHELOR'S DEGREE IN INDUSTRIAL ELECTRONICS AND AUTOMATIC CONTROL ENGINEERING (Syllabus 2009). (Compulsory subject). BACHELOR'S DEGREE IN MECHANICAL ENGINEERING (Syllabus 2009). (Compulsory subject).

Academic year: 2026 **ECTS Credits:** 6.0 **Languages:** Catalan, Spanish

LECTURER

Coordinating lecturer:	MOHAMMAD REZA HASHEMI
Others:	Primer quadrimestre: GEMMA CANTÓ ATIENZA - N3012, N3021 MOHAMMAD REZA HASHEMI - N3011, N3012, N3021, N3111, N3112, N3121 DAVID LAPARRA VICENTE - N3011, N3111, N3112 DAVID MORENO MAESTRO - N3121, N3211, N3212, N3221

PRIOR SKILLS

Previous knowledge of basic thermodynamics and heat transfer.
Basic previous knowledge of the behavior of fluids.
Integral and differential calculus.

REQUIREMENTS

340022 - Chemistry
340023 - Physics I
340026 - Advanced calculus

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
1. CE7. Knowledge of applied thermodynamics and heat transfer. Basic principles and its application in solving engineering problems.

Transversal:
3. SELF-DIRECTED LEARNING - Level 2: Completing set tasks based on the guidelines set by lecturers. Devoting the time needed to complete each task, including personal contributions and expanding on the recommended information sources.
4. EFFICIENT ORAL AND WRITTEN COMMUNICATION - Level 2. Using strategies for preparing and giving oral presentations. Writing texts and documents whose content is coherent, well structured and free of spelling and grammatical errors.
5. TEAMWORK - Level 2. Contributing to the consolidation of a team by planning targets and working efficiently to favor communication, task assignment and cohesion.

TEACHING METHODOLOGY

- KNOWLEDGE IMPARTATION: Expository and participatory theoretical classes, consisting of the presentation and development of theoretical foundations and, if necessary, the completion of standard exercises. The materials to be used will be available to students in the Digital Campus section designated for the subject.

- APPLIED KNOWLEDGE LEARNING: Practical problem-solving classes, where maximum student participation will be encouraged through their direct involvement in solving exercises. After the instructor presents and solves a problem, students must individually complete the assigned exercises in class or outside of class. Students will have access to the problems to be completed in advance in the Digital Campus section designated for the subject.

- SUBMISSION OF EXERCISES AND FEEDBACK: Students submit problems. Submissions will consist of individual solutions, to be completed in class or outside of class, to one or more problems from the list, or similar problems, which the student will have on the Digital Campus. This activity will be assessed and a rubric will be provided for its completion. Students will be able to receive feedback upon submitting corrected problems.

- LEARNING THROUGH EXPERIMENTATION AND SIMULATION: Practical laboratory and simulation classes, conducted directly by students, guided by the instructor, will allow them to directly observe relevant aspects of the theory developed. The scripts for the practical exercises to be developed will be available prior to their completion in the section of the Digital Campus designated for the subject. Students will submit a copy of the experimental data obtained to the instructor. Students must then complete a report on the practical exercises. For this purpose, students will have access to a rubric for completing practical exercises, which will be posted on the Digital Campus. This report will be assessed and must be submitted before the date indicated by the professor.

- TUTORIALS: Group or individual tutorials that will allow students to obtain clarifications from the professor regarding the subject matter, enabling them to effectively follow the course.

- INDIVIDUAL WRITTEN TESTS: Students will take two midterm exams (individual written tests) covering all the theoretical knowledge and problems developed in the course. In the first midterm exam (CP1), the knowledge developed in the first part of the semester will be assessed, and will be taken approximately halfway through the semester. In the second midterm exam (CP2), the knowledge developed in the second part of the semester will be assessed, and will be taken at the end of the semester on the date established by the EPSEVG (Final Assessment period). A Final Assessment of the subject (CFinal) will be conducted during the Final Assessment period. Students with a CP1 grade lower than 3.50 may take this Final Control, which will replace Partial Control 2 (CP2), on a completely optional basis. A Global Control (CGlobal) will also be carried out to re-evaluate all the theoretical knowledge and problems developed in the subject on the date set by the EPSEVG (Re-evaluation period).

LEARNING OBJECTIVES OF THE SUBJECT

When the student finishes the subject, he/she has to be capable of:
· Understanding the principles of applied thermodynamics and heat transfer.
· Knowing the principles of thermal equipment and generators.
· Analyzing and solving problems in the area of thermal engineering.
· Interpreting, analyzing, synthesizing and extracting conclusions of results of measurements and tests.
· Writing texts with the structure adapted to the aims of communication.
· Knowing and putting into practice the dynamics teamwork.
· Carrying out assignments from basic directions given by the teacher.

STUDY LOAD

Type	Hours	Percentage
Self study	90,0	60.00
Hours small group	7,5	5.00
Hours large group	52,5	35.00

Total learning time: 150 h

CONTENTS

TOPIC 1: FUNDAMENTAL CONCEPTS OF THERMODYNAMICS. PROPERTIES OF PURE SUBSTANCES

Description:
1.1. Concept of energy. Classification of energy forms. Energy conversion devices: efficiency and environmental impact.
1.2. Concept of a thermodynamic system. Classification and examples.
1.3. Concept of thermodynamic properties. Examples.
1.4. State of a thermodynamic system: Postulate of state, equations of state, state functions, and path functions.
1.5. Thermodynamic processes: Quasi-static, reversible, and irreversible processes.
1.6. Concept of a thermodynamic cycle. Example.
1.7. Concept of a pure substance. Phases of a pure substance.
1.8. State diagrams of a pure substance: P-v-T surface, T-v diagram, P-v diagram, P-T diagram, and other thermodynamic diagrams (T-s, h-s, P-h).
1.9. Concepts of saturation temperature, saturation pressure, subcooled liquid, saturated liquid, saturated vapor, wet vapor, and superheated vapor.
1.10. Tables of thermodynamic properties (T, P, v, u, h, s) of water and the refrigerants R-134a and R-410A.
1.11. Compressibility factor (Z). Study of some significant equations of state.

Specific objectives:
At the end of this teaching unit, the student must be able to:
- Identify and explain specific vocabulary related to thermodynamics by precisely defining basic concepts such as: energy, system, state, state postulate, state function, path function, equilibrium, process, cycle, pure substance.
- Classify forms of energy and define energy conversion efficiencies.
- Describe and analyze the implications of energy conversion on the environment.
- Interpret property diagrams: P-v, T-v, and P-T, and P-v-T surfaces of pure substances, as well as other thermodynamic diagrams: T-s, h-s, P-h.
- Use procedures to determine thermodynamic properties of pure substances from property tables.
- Use the ideal gas equation of state and establish its applicability to problems involving gases and vapors.
- Interpret the concept of compressibility factor and solve problems involving this concept.
- Solve problems with some of the most significant equations of state.

Related activities:
A1. Problems of properties of pure substances and equations of state.
A6. First individual written test.
A7. Computer practice: Calculation of volumetric properties of pure fluids with cubic equations of state and comparison with MINIREF software.

Full-or-part-time: 32h
Theory classes: 12h
Laboratory classes: 2h
Self study : 18h

TOPIC 2: FIRST AND SECOND PRINCIPLES OF THERMODYNAMICS

Description:
2.1. Work due to volume change in a reversible process in a closed system.
2.2. First law of thermodynamics for a static closed system.
2.3. Heat capacities cv and cp. Calculation of internal energy and enthalpy increases.
2.4. First law of thermodynamics for an open system in steady state.
2.5. Applications of the first law to the analysis of nozzles, diffusers, compressors, steam turbines, heat exchangers, and mixers.
2.6. Second law of thermodynamics: Thermal efficiency of a heat engine. Coefficient of performance of a refrigeration engine and a heat pump. Statements of the second law.
2.7. Carnot cycle. Heat engine, refrigerator, and Carnot heat pump.
2.8. Clausius inequality and the entropy state function. Calculation of entropy changes in reversible processes in ideal gases.
2.9. Application of the second law to turbines, pumps, and compressors: isentropic efficiency.

Specific objectives:
At the end of this teaching unit, the student must be able to:
- Solve work problems involving volume change in reversible processes and closed systems.
- Define heat capacities at constant volume and constant pressure and relate them to the calculation of internal energy and enthalpy increases.
- Solve energy balance problems in static closed systems involving ideal gases and pure substances (based on tables of thermodynamic properties).
- Solve steady-state energy balance problems for common devices: nozzles, diffusers, compressors, steam turbines, heat exchangers, mixers.
- Define the thermal efficiency of a heat engine and the coefficient of performance of a refrigeration engine and a heat pump.
- Establish the Kelvin-Planck and Clausius statements of the Second Law.
- Describe the Carnot Cycle and establish the thermal efficiency of the Carnot heat engine and the coefficient of performance of the refrigerator and the Carnot heat pump.
- Define the state function entropy as a consequence of the second law.
- Calculate entropy changes in reversible processes in ideal gases.
- Apply the concept of isentropic efficiency to analyze the operation of turbines, pumps, and compressors.

Related activities:
A.2. Problems of the first and second principles of thermodynamics.
A.6. Second individual written test.

Full-or-part-time: 32h
Theory classes: 12h
Self study : 20h

TOPIC 3: PRINCIPLES OF HEAT TRANSMISSION. APPLICATIONS.

Description:
3.1 Introduction to heat transfer mechanisms.
3.2. Heat transfer by conduction: Fourier's Law. Plane, cylindrical, and spherical walls. Thermal resistance to conduction and composite walls.
3.3. Heat transfer by convection: Newton's Law. Thermal resistance to convection. Introduction to the calculation of convection coefficients in forced convection and natural convection.
3.4. Heat transfer by radiation: Stefan-Boltzmann Law. Emissivity of a surface. Radiation heat exchange between gray surfaces. Radiation heat transfer coefficient. Thermal resistance to radiation.
3.5. Heat transfer by combined mechanisms. Overall heat transfer coefficient (U). Application to the calculation of thermal insulation.

Specific objectives:
At the end of this teaching unit, the student must be able to:
- Interpret the basic mechanisms of heat transfer (conduction, convection, and radiation) and use the fundamental laws that govern them to solve simple problems.
- Identify the heat transfer mechanisms involved in a given problem.
- Apply the thermal resistance method to solve various heat transfer problems encountered in practice (with plane, cylindrical, and spherical geometries), for individual or combined mechanisms.

Related activities:
A3. Problems of heat transfer principles.
A8. Laboratory: Determination of thermal conductivity of an insulating material.
A11. Second individual written test.

Full-or-part-time: 28h
Theory classes: 10h
Laboratory classes: 1h
Self study : 17h

TOPIC 4: FUNDAMENTALS OF TECHNICAL THERMODYNAMICS

Description:
4.1. Steam power plant cycles: The Rankine cycle. Irreversibilities. Superheating and reheating. Regenerative power cycle.
4.2. Gas turbine power plant cycles: Brayton cycle. Irreversibilities.
4.3. Reference cycles for reciprocating internal combustion engines: Otto cycle. Diesel cycle. Semi-diesel or dual cycle.
4.4. Refrigeration cycle by mechanical vapor compression of a refrigerant. Irreversibilities. Heat pump.
4.5. Mixtures of ideal gases and humid air: Dalton's law of additive pressures. Properties of humid air (specific humidity, relative humidity, dew point temperature, specific enthalpy). Psychrometric diagram. Representation of air conditioning processes.

Specific objectives:
At the end of this teaching unit, the student must be able to:
- Interpret and solve problems related to basic cycles of steam power plants.
- Interpret and solve problems related to the basic cycles of gas turbine power plants and reciprocating internal combustion engines.
- Interpret and solve problems related to the basic mechanical vapor compression refrigeration cycle, which is the basis for the operation of refrigerators, heat pumps, and some air conditioning systems.
- Define and perform calculations using Dalton's model to describe the P-v-T behavior of ideal gas mixtures (Dalton's Law).
- Define and perform calculations using concepts related to humid air (specific humidity, relative humidity, dew point temperature, and specific enthalpy).
- Use the psychrometric chart to determine some properties of humid air.
- Calculate some humid air conditioning processes (sensible heating, sensible cooling, cooling, and dehumidification of humid air).

Related activities:
A4. Problems of fundamentals of Technical Thermodynamics.
A9. Laboratory: Determination of the heat balance and the COP of a heat pump as a function of time.
A10. Computer practice: Analysis of the operation of a conventional power plant with the "PROPAGUA" software.
A11. Second individual written test

Full-or-part-time: 32h
Theory classes: 10h
Laboratory classes: 3h
Self study : 19h

TOPIC 5: INTRODUCTION TO THERMAL EQUIPMENT AND GENERATORS

Description:
5.1. Heat exchangers: Classification. Overall heat transfer coefficient (U). Energy balance equations. Logarithmic mean temperature difference (LMTD). F graphs for different types of heat exchangers. Calculation Method F-LMTD.
5.2. Fuels and combustion: Classification of fuels. Calorific value of the fuel. Chemical equations of combustion (stoichiometric combustion, combustion with air excess and defect).
5.3. Boilers or steam generators: Classification. Use of the boilers. Mass and energy balance applied to a boiler. Efficiency of a boiler.

Specific objectives:
At the end of this teaching unit, the student must be able to:
- Identify and classify the different types of heat exchangers.
- Establish the equation for calculating the overall heat transfer coefficient (U).
- Perform a general energy balance on heat exchangers.
- Analyze the thermal behavior of heat exchangers based on the F-DTML method.
- Interpret basic concepts related to fuels and combustion.
- Apply the principle of conservation of mass to reactive systems to perform calculations and determine balanced combustion equations.
- Classify the different types of boilers and perform mass and energy balances for them.
- Determine the thermal efficiency of a boiler.

Related activities:
A5. Problems of introduction to equipment and thermal generators.
A11. Second individual written test.

Full-or-part-time: 26h
Theory classes: 10h
Self study : 16h

GRADING SYSTEM

The different concepts that make up the continuous assessment are:
- INDIVIDUAL WRITING TESTS: 77%
- DELIVERY OF SOLVED PROBLEMS: 10%
- PRACTICES (LABORATORY AND SIMULATION): 13%

To obtain the final grade of FENT, the following equation of the evaluation will be applied:

[1] Final Note from FENT = Note CP1*0.385 + Note CP2*0.385 + Note Delivery Problems*0.10 + Practice Note*0.13

Students who have obtained a grade equal to or greater than 3.5 in the Note of CP1, will necessarily have to do the CP2. Students who have obtained a grade lower than 3.5 in the Note of CP1, may be presented as an optional to a Final Control (CFinal) instead of CP2. This CFinal will be held on the same day and time as the CP2, within the Final Evaluation Period. The equation of the evaluation, to obtain the final grade of FENT, in this case is:

[2] Final Note from FENT = Note CFinal*0.77 + Note Delivery of Problems*0.10 + Practice Note*0.13

There are no minimum scores in any of the previous evaluative acts at the time of applying equations [1] or [2].

RE-EVALUATION:
The student who is suspended and has a Final Note from FENT between 2.0 and 4.9 , has the right to appear for the Re-evaluation of the FENT subject.
The re-evaluation will consist of a Global Control of theory and problems of the subject that will weigh 77%.
Once the Global Control (CGlobal) of re-evaluation is done, the final grade of Re-evaluation will be obtained from the following expression:

Final Note Re-evaluation = Note CGlobal*0.77 + Note Problem Delivery*0.10 + Practice Note*0.13

The Final Note from FENT after the re-evaluation will be:
a) If the "Final Note Re-evaluation" is higher than 7.0: Final Note from FENT = 7.0
b) If the "Final Note Re-evaluation" is between 5.0 and 7.0: Final Note from FENT = Final Note Re-evaluation.
c) If the "Final Note Re-evaluation" is less than 5.0: The highest grade between the Final Note Re-evaluation and the Final Note from FENT prior to the re-evaluation will be taken as the Final Note from FENT.

EXAMINATION RULES.

- Each of the two individual written exams (Partial Controls) consist of two parts: a theory test (which may constitute up to 30% of the test score) and a certain number of problems (up to 100% completion of the test grade). Both tests have the same evaluative weight (38.5%). A minimum grade of the partial controls is not required.

- The Final Control (CFinal) will consist of two parts: a theory test (which may constitute up to 30% of the test score) and a certain number of problems (up to completing 100% of the test grade)). This test has an evaluative weight of 77%. A minimum grade of the Final Control is not required.

- Deliveries of the resolution of practical problems solved individually will be evaluated following the rubric for the realization of the delivery of resolution of problems, which the student will have in advance. The problems solved must be delivered personally to the teacher or through the Campus Athena, and within the allotted time period.

- The reports of laboratory practices will be evaluated according to the rubric established for the realization of them and that the students will have previously. To have a note of the laboratory practices, it is essential to have done the practices in person and present the corresponding reports with the group with which the laboratory practice was carried out.

- If a student presents deliveries of problems and / or practices, at the end he / she will have a grade of the subject even if he / she has not been submitted to the individual written tests (partial controls or final control).

RE-EVALUATION:

- When the Final Score of FENT is lower than 5.0 but equal to or higher than 2.0, you can opt for the Reevaluation. In this case, the theory and problems contents of CP1 and CP2 are reappraised. In the Reevaluation there will be a Global Control of the subject (CGlobal) and this will have a weight of 77%.

- The Global Control (CGlobal) of the re-evaluation will consist of two parts: a theory test (which may constitute up to 30% of the test score) and a certain number of problems (up to 100% of the grade of the test).

BIBLIOGRAPHY

Basic:
- Çengel, Yunus A.; Boles, Michael A.; Kanoglu, Mehmet. Termodinámica [on line]. 9a ed. México, D.F: McGraw-Hill, 2019 [Consultation: 14/02/2024]. Available on: https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?pq-origsite=primo&docID=5808940. ISBN 9781456272081.
- Moran, Michael J.; Shapiro, Howard N. Principles of engineering thermodynamics. 8th ed. Hoboken, N.J: John Wiley & Sons, 2015. ISBN 9781118412930.
- Çengel, Yunus A.; Ghajar, Afshin J. Transferencia de calor y masa : fundamentos y aplicaciones [on line]. 6a ed. México, Madrid: McGraw-Hill, 2020 [Consultation: 15/02/2024]. Available on: https://www-ingebook-com.recursos.biblioteca.upc.edu/ib/NPcd/IB_BooksVis?cod_primaria=1000187&codigo_libro=10213. ISBN 9781456277215.
- Llorens, Martín; Miranda Barreras, Ángel Luis. Ingeniería térmica. Barcelona: Marcombo, 2009. ISBN 9788426715319.

Complementary:
- Çengel, Yunus A.; Cimbala, John ; Ghajar, Afshin J. Fundamentals of thermal-fluid sciences. 6th ed. New York: McGraw-Hill, 2022. ISBN 9781260597585.
- Kaminski, Deborah A.; Jensen, Michael K. Introduction to thermal and fluids engineering. New York: John Wiley & Sons, 2005. ISBN 0471268739.
- Dutta, Binay K.. Heat transfer: principles and applications. New Delhi: PHI Learning, 2006. ISBN 9788120316256.
- Chandra, Ramesh. Refrigeration and air conditioning. New Delhi: PHI Learning, 2010. ISBN 9788120339156.

RESOURCES

Other resources:

UNIVERSITAT POLITÈCNICA
DE CATALUNYA
BARCELONATECH

In computer classrooms of EPSEVG, the computer programs (software) used in the course of FENT are installed.