TECHNICAL THERMODYNAMICS

Academic Year: 2019-2020

Identification and characteristics of the course			
Code	501069	ECTS Credits	6
Course name (English)	Technical Thermodynamics		
Course name (Spanish)	TermodinámicaTécnica		
Degree program	DEGREES IN MECHANICAL ENGINEERING, ELECTRICAL AND ENGINEERING AND ELECTRONICS AND AUTHOMATICS ENGINEERING (Industrial branch) AND DEGREE IN MATERIALS ENGINEERING		
Faculty/School	Industrial Engineering School		
Semester	4º	Type of course	Mandatory
Module	CRI		
Matter	Thermodynamics and Fluids Mechanics		

Instructor/s			
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Area	Applied Physics
Department	Applied Physics
Coordinator	Carmen Mª. González García

Competences*

Basic competences (CB):
CB1 – To demonstrate that the knowledge has been acquired and understood, within a study area that includes contents starting from a high school level, and includes knowledge of advanced books, but also includes updated and innovating concepts.
CB2 – To apply the knowledge to a job, and acquired the skills that can be demonstrated by the development and description of arguments and resolution of problems, in the area of study.
CB3 – To acquire the skill of interpreting relevant data (within the area of study) to asses judgements including a reflexion on relevant issues of social, scientific and ethical character.
CB4 – To transfer information, ideas, problems and solutions to a specialized and non-specialized public.
CB5 – To develop learning skills needed to undertake further studies with a high degree of autonomy.

General skills (CG):
CG1 – Skills for the writing, signing and development of projects in the frame of engineering, aimed to the construction, reconstruction, reparation, conservation demolition, installation, set-up or exploitation of: structures, mechanical equipment, energetic installations, electrical

and electronic installations, industrial installations and plants and automatization and fabrication processes.
CG3 – Knowledge in basic and technological subjects, allowing the students to get knowledge on new methods and theories and provide them of versatility to adapt to new situations.
CG4 – Skills to solve problems with initiative, creativity, critical thinking, decision taking, skills to communicate and transfer knowledge, and skills in the field of engineering.
CG5 – Skills to make tests, measurements, calculations, expert reports, studies, and other analogous works in the field of the engineering studies.
CG6 – Skills in the handling of specifications and specific rules.
CG7 – Skills to analyze and evaluate the social and environmental impact of the technical solutions.
CG11 - Knowledge, understanding and capacity to apply the legal frame of the professional activities of an Industrial Technical Engineer.

Transversal Competences (CT):
CT1 – To get the knowledge on basic and technological subjects, allowing to the inclusion of new methods and theories, and gives versatility to be adapted to new situations.
CT2 – To solve problems and to take decisions with initiative, creativity and critical thinking.
CT3 – To communicate and transfer knowledge, abilities in the field of engineering.
CT4 – To find, analyze, criticize, relate, structure and synthesize scientific and technical information from different sources.
CT5 – To apply information and communication technologies.
CT6 – To have motivation in regards to motivation and continuous improvement.
CT7 – To be able to effectively communicate in other languages, mainly in English.
CT8 – To have an ethical, responsible and respectable attitude with people and environment.
CT9 – To be able to work efficiently in multidisciplinary teams assuming different roles and responsibilities with absolute respect to the fundamental rights of equality between men and women.
CT10 – Ability to analyse and measure the social and environmental impact of technical solutions.

Specific Competences CRI (CECRI):
CECRI1 – Knowledge on applied thermodynamics and heat transfer. Basic principles and their application to the resolution of engineering problems.

Contents

Brief description of the contents

Applications of the First Principle of Thermodynamics (open systems). Second Principle: energetic and exergetic analysis. Thermodynamical cycles of themal engines. Aplications of heat transfer to engineering processes.

Subject topics

Denomination of topic 1: **Heat transfer**
Contents of topic 1: Heat transfer by conduction. Heat transfer by convection. Heat transfer by radiation. Applications of conduction, convection and combined radiation. Heat exchangers.
Practical activity 1.1: **Computer lecture (O1. 4h)**. Using an excell file, analysis of heat transfer processes under steady flow regime will be made.
Title: Thermal insulation of the exterior Wall according to the Technical Code
Practical activity 1.2: **Problems resolution. Questionary 1 (C1. 3h)**. The student will solve problems about heat transfer.

Denomination of topic 2: **First principle of Thermodynamics. Open systems** Contents of topic 2: Open systems. Variation of the energy stored by an open systems. Stationary regime. Conservative systems. Applications of the first principle for open systems: nozzles, diffusers, venturimeters, pipes, pumps, compressors, turbines, boilers, heat exchangers and solar collectors. Practical activity 2.2: **Problems resolution. Questionary 2 (C2. 3h)**. The student will solve problems about nozzles, diffusers, venturimeters and pipes. Practical activity 2.3: **Problems resolution. Questionary 3 (C3. 4h)**. El The student will solve problems about pumps, compressors, turbines, boilers, heat exchangers and solar collectors.
Denomination of topic 3: **Second principle of thermodynamics** Contents of topic 3: Insufficiency of First Principle. Previous concepts: thermal source, thermal engine and heat pump. Statement of the Second Principle. Equivalences. Reversible and irreversible processes.
Denominación del tema 4: **Ciclo de Carnot** Denomination of topic 4: **Carnot cycle** Contents of topic 4: Cicle and Carnot engine. Carnot cycle efficiency. Carnot refrigeration cycle. Carnot Theorem. Corolares. Application to thermal engines and heat pumps. Practical activity 4.1: **Seminar (S1.1h)**. A seminar aimed to delve into the analysis of the energy balances involved in the sizing of thermal engines and refrigerators will be made. Practical activity 4.2: **Problems resolution. Questionary 4 (C4. 3h)**. The student will solve problem involving thermal engines and refrigerators
Denomination of topic 5: **Entropy. Mathematical formulation of the Second Principle** Contents of topic 5: Clausius Theorem. Entropy. Mathematical formulation of the Second Principle for irreversible processes. Entropy diagram or T-s. Calculation of the entropy change in reversible processes. Relation between heat and work exchanged in reversible and irreversible processes. Isolated systems. Practical activity 5.1: **Problems resolution. Questionary 5 (C5. 3h)**. The student will solve practical problems related to the determination of entropy in engineering.
Denomination of topic 6: **Introduction to exergetic analysis** Contents of topic 6: Exergetic transformations. Exergy. Exergy of a closed system in the presence of a unique heat source. Exergy of heat. Exergy of an open system under steady flow conditions. Exergy lost in irreversible processes. Practical activity 6.1: **Seminar (S2. 1h)**. The student will solve practical problems aimed to strength the knowledge on the analysis of entropy and exergy balances. Practical activity 6.2: **Computer lecture (O2. 4h)**. Using an excel file the energetic and exergetic analysis of a heat exchanger will be performed. Title: Sizing and thermodynamical analysis of a tube and shell heat exchanger Practical activity 6.3: **Resolution of problems. Questionary 6 (C6. 3h)**. The student will solve practical problems related to the determination od exergy in engineering.
Denomination of topic 7: **Introduction to the analysis of cycles**. Contents of topic 7: Cycles and thermal engines. Classifications of thermal engines. Theoretical and real cycles. Efficiencies. Carnot cycle as comparative cycle for thermal engines. Maximun efficiency cycles. Regenerative cycles, Equivalent Carnot cycles. Average temperatures.
Denomination of topic 8: **Steam turbine cycles** Contents of topic 8: Rankine cycle. Reheating cycle. Characteristics improving the cycle. Intermediate reheating. Practical activity 8.1: **Computer lecture (O3. 2h)**. Using an excell file, the thermodynamic analysis of a thermosolar plant will be made.

Title: Thermodynamic analysis of a Thermosolar Plant
Practical activity 8.2: **Problems resolution. Questionary 7 (C7. 3h)**. The student will solve practical problems related to steam thermal power plants.

Denomination of topic 9: **Cycles of gas turbines**
Contents of topic 9: Non-regenerative Brayton cycle. Efficiency. Other gas turbine cycles. Efficiency. Reaction engines. Cogeneration.
Practical activity 9.1: **Problems resolution. Cuestionary 8 (C8. 3h)**. The student will solve problems related to the calculation of gas turbine engines.

Denomination of topic 10: **Gas cycles. Alternative internal combustion engines**
Contents of topic 10: Internal combustion engines: classification. Otto engine and Otto cycle. Efficiency. Diesel engine and cycle. Efficiency. Comparison between Diesel and Otto cycle. Cogeneration.
Practical activity 10.1: **Seminar (S3. 1h)**. A seminar aimed to strengh the knowledge on cogeneration, focussing on alternative internal combustion engines in micro-cogeneration will be carried out.
Practical activity 10.2: **Problems resolution. Cuestionary 9 (C9. 3h)**. The student will solve problems related to alternative internal combustion engines.

Learningactivities

Student workload in hours		Lectures and practical activities					Homework
Unit / Assessment	Total	GG	S	O	L	TP	EP
1.-Heat transfer	19	5		4			10
2.- 1stPrinciple	18	6			2		10
3.- 2ºPrinciple	7	3					4
4.- Carnotcycle	15	5	1			1	8
1erPartialExam (1-4)	5	2					3
5.- Entropy	14	4					10
6.- Exergy	20	4	1	4		1	10
7.- Cycles	5	2					3
8.- Steam turbine engine	18	5		2		1	10
9.- Gas turbine engine	8	2					6
10.- IC engine	13	4	1				8
Finalexam	8	3					5
Total	150	45	3	10	2	3	87

GG: Lectures (100 students)
S: Seminar (40 students)
O: Computer (30 students)
L: Lab (15 students)
TP: Small group (10 students)
EP: Homework and exams preparation

Teaching methodology

Among the teaching methodologies included in the formative program, in this course the following are used:

Teaching methodology	Check with an "X" the ones used
1. Explanation and discussion of contents	x
2. Solution, analysis and discussion of examples and exercises	x
3. Oral presentation of assignments	
4. Development of practical cases in labs, computer rooms, seminars, etc	x

5. Attention to the student and advice of the assignments in small groups	**x**
6. Search of information prior to the explanation of the contents of an unit or search of complementary information once the activities of a unit have been developed	**x**
7. Elaboration of assignments either individually or in groups	
8. Study of each unit: study of contents, preparation of exercises or cases, preparation of the final exam, etc.	**x**

Learningresults

The students will acquire a general vision on Thermodynamics,heat transfer and the skills needed to apply practical questions and problems related to engineering, analyzing their results to provide adequate decisions.

Evaluation systems

Description of evaluation activities
Ordinary call
Evaluation activity 1: (80%) CE1-4;
One partial exam will be made. It will be qualifying provided the mark is equal or above 7 over 10. The hangout of practical problems (evaluation activity 3) and active participation during lectures, with good behaviour, will allow reducing the qualifying minimum mark in this exam to 5.5 over 10.

 Those students who do not pass the exam will have to attend the final exam and be tested of the whole subject. The final score will be that of the final exam.

 The students who pass the exam, will only be tested of the remainder subject. In this cases, the mark of activity 1 will be:40%*Mark 1P+60%*Mark final exam. A minimum mark of 3.5 over 10 in the final exam will be needed to apply this equation.If the minimum score is not reached, the final grade will be that obtained in the final exam.

The exam punctuations will be in the range 0-10 and, as it is illustrated in the table, theevaluation activity 1 will mean 80% of the final subject mark.
Important: Obtaining a minimum of 4.5 points over 10 is mandatory in order to allow theaccountancy of the remaining evaluation activities in the final subject mark.

Evaluation activity 2: (8% Non recoverable) CE1-5
a) Laboratory session:
The attendance to practical computer lectures will be taken into account, and the hang out report made by the students will also be evaluated The mark of this activity will be “PASS” or “NOT PASS”. The consideration or “NOT PASS”, will be applied in the case of non attendance or inadequate behaviour at the lab; this implies attending the session again.
b) Computer practical lectures:
The attendance to practical computer lectures will be taken into account, and the hang out questionary made by the students will also be evaluated. The mark will be in the in the range 0- 10 and will mean a 8% of the subject final mark.

Evaluation activity 3: (8% No recuperable) CE1-5
Two questionaries involving problems of different topics will be solved. The questionaries will be marked in the range 0-10. This evaluation activity will mean 8% of the final mark.
Evaluation activity 5: (4% Non recoverable)

Attendance to lectures will be controlled. This contribution will be marked in the interval 0-10 and will mean a 4% of the final mark. An adequate behaviour at lectures is necessary to get this punctuation.

Comment (1)
In case the criteria stablished to pass the subject are not overtaken and the mark is greater than 4, the final official mark will be 4.

Comment (2) about extraordinary call
The extraordinary call will consist of an exam about the whole subject (evaluation activity 1). The mark of activities 2, 3 and 5 will be kept during one academic course. After that moment, if the student wants those activities to be considered, he will have to repit them.

Evaluation activities	Rango establecido en la memoria verificada	Convocatoria ordinaria	Convocatoria extraordinaria	Evaluación global
1. Final theoretical/practical exam and/or partial cummulative and/or qualifyingexams.	0%–80%	80%(1)	80%	80%
2. Academic progress of practical problems at: classroom, laboratory, computer room, technical visits, etc.	0%–50%	8%(1)	8%(1,2)	8%(1,2)
3. Resolution and hang out of activities (real cases, problems, informes, reports, projects etc.), individuallly and/or in group (GG, SL, ECTS).	0%–50%	8%(1)	8%(1,2)	8%(1,2)
4. Active partiipation at classroom	0%–10%			---
5. Attendance to presencial activities	0%–10%	4%(1)	4%(1,2)	4%(1,2)

Bibliography and other resources

Basic bibliography

1. Notes on Thermodynamics and heat transfer (Virtual Campus).
2. Moran-Shapiro. Fundamentals of technical thermodynamics. (Ed. Reverté, Barcelona, 2004)
3. ÇENGEL. Heat and mass transfer. (McGraw-Hill. México, 2007)
4. Juarez and Morales. Termodinámica Técnica. Teoría y 222 ejercicios resueltos. (Ed. Paraninfo, 2015)

Complementary bibliography

1. Ramiro, González, Sabio y González, Termodinámica Técnica (UEx, 1994).
2. Çengel-Boles, Thermodynamics. (McGraw-Hill, 2006).
3. Kreith, Principles of heat transfer (Thomson, 2001)

Web sites

www.idae.es (Instituto para la diversificación y ahorro de la energía)
www.acogen.es (asociación española de cogeneración).
www.mityc.gob.es (ministerio de industria, turismo y comercio)

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