Teaching Guide				
Identifying Data				2022/23
Subject (*)	Thermodynamics and Engineering Thermodynamics		Code	631G03014
Study programme	Grao en Máquinas Navais			
Descriptors				
Cycle	Period	Year	Type	Credits
Graduate	1st four-month period	Second	Obligatory	6
Language	SpanishEnglish			
Teaching method	Face-to-face			
Prerequisites				
Department	Ciencias da Navegación e Enxeñaría Mariña			
Coordinador	Baaliña Insua, Alvaro	E-mail	alvaro.baalina@udc.es	
Lecturers	Arias Fernández, Ignacio Baaliña Insua, Alvaro Romero Gomez, Javier	E-mail	ignacio.arias@udc.es alvaro.baalina@udc.es j.romero.gomez@udc.es	
Web	https://estudos.udc.es/es/subject/631G03V01/631G03014			
General description	This subject developes basic concepts for the understanding of the greater part of the processes related with energy in an installation, both on board and ashore. As an example, allows to know, analyse and optimise the operation of an internal combustion engine,a boiler or a turbine. Without the knowledge of the thermodynamic principles results very difficult the understanding of many subjects of the study plan, as Gas and Steam Turbines, Internal Combustión Engines, Auxiliary Systems of ship, Steam Generators, Refrigeration, etc. To attend the course is advisable to have previous knowledges of Physics and Mathematics.			

Study programme competences	
Code	Study programme competences
A1	CE01 - Realizar unha garda de máquinas segura
A2	CE02 - Facer funcionar a maquinaria principal e auxiliar e os sistemas de control correspondentes.
A6	CE06 - Mantemento e reparación das máquinas e o equipo de a bordo.
A73	CE73 - Modelizar situacións e resolver problemas con técnicas ou ferramentas físico-matemáticas.
A74	CE74 - Avaliar de forma cualitativa e cuantitativa os datos e resultados, así como a representación e interpretación matemáticas de resultados obtidos experimentalmente.
A78	CE78 - Adquirir coñecementos de termodinámica aplicada e da transmisión da calor.
A86	CE86 - Operar, reparar, manter e optimizar as instalacións auxiliares dos buques que transportan cargas especiais, tales como quimiqueros, LPG, LNG, petroleiros, cementeros, Ro- Ro, Pasaxe, botes rápidos, etc.
A89	CE89 - Poñer en marcha e operar novas instalacións en buques, instalacións marítimas e industriais.
A90	CE90 - Operar, reparar, manter e optimizar a nivel operacional as instalacións industriais relacionadas coa enxeñería mariña, como motores alternativos de combustión interna e subsistemas; turbinas de vapor e de gas, caldeiras e subsistemas asociados; ciclos combinados; equipos eléctricos, electrónicos, e de regulación e control; as instalacións auxiliares, tales como instalacións frigoríficas, instalacións de aire acondicionado, plantas potabilizadoras, grupos electrógenos, etc.
A95	CE95 - Coñecer o balance enerxético xeneral, incluíndo o balance termo-eléctrico, así como a xestión eficiente da enerxía respectando o medio ambiente.
A96	CE96 - Realización de auditorías enerxéticas de instalacións marítimas.
A99	CE99 - Ter a capacidade para exercer como Oficial de Máquinas da Mariña Mercante, unha vez superados os requisitos esixidos pola Administración Marítima.
A100	CE100 - Ter a capacidade para exercer como oficial ETO da Mariña Mercante, unha vez superados os requisitos esixidos pola Administración Marítima.
B2	CB2 - Aplicar os coñecementos no seu traballo ou vocación dunha forma profesional e posuír competencias demostrables por medio da elaboración e defensa de argumentos e resolución de problemas dentro da área dos seus estudos

B3	CB3 - Ter a capacidade de reunir e interpretar datos relevantes para emitir xuicios que inclúan unha reflexión sobre temas relevantes de índole social, científica ou ética
B5	CB5 - Ter desenvolvido aquelas habilidades de aprendizaxe necesarias para emprender estudos posteriores con un alto grao de autonomía.
B7	CG02 - Resolver problemas de forma efectiva.
B16	CG11 - Valorar criticamente o coñecemento, a tecnoloxía e a información dispoñible para resolver os problemas cos que deben enfrontarse.
C3	CT03 - Utilizar as ferramentas básicas das tecnoloxías da información e as comunicacións (TIC) necesarias para o exercicio da súa profesión e para a aprendizaxe ao longo da súa vida.
C7	CT07 - Desenvolver a capacidade de traballar en equipos interdisciplinares ou transdisciplinares, para ofrecer propostas que contribúan a un desenvolvemento sostible ambiental, económico, político e social.

Learning outcomes			
Learning outcomes	Study programme competences		
Analysis and synthesis of the thermodynamic concepts.	A1	B2	C3
Capacity to reason and comprise the energetic interactions in diverse systems.	A2	B3	C7
Capacity to solve energetic and optimisation problems through the concept of entropy and irreversibility.	A6	B5	
Planning and decision making regarding the energetic management of industrial installations.	A73	B7	
Critical reasoning about the applicable physical models	A74	B16	
Habit of study and structuring of the information through tables and two-dimensional diagrams of thermodynamic parameters.	A78		
The following competencies included in Table A-III / 1 of the STCW Code as amended by Manila; Function: Marine	A86		
engineering at operational level	A89		
-1.1 Maintain a safe engineering watch	A90		
-1.2 Operate main and auxiliary machinery and associated control systems	A95		
	A96		
	A99		
	A100		

Contents	
Topic	Sub-topic
1.- INTRODUCTION	1.1.- OBJECTIVES OF THE THERMODYNAMICS. 2.1.- THERMODYNAMIC SYSTEM AND PROPERTIES 2.1.1.- Thermodynamic system. 2.1.2.- Thermodynamic properties. Primitive-Derived. Intensive-Extensive. 2.1.3.- States of a system. Postulate I (of state). Postulate II (of equilibrium). 2.1.4.- Thermodynamic processes.

2.- WORK, ENERGY AND HEAT.	1.2.- WORK. FORMS OF QUASI STATIC WORK . 1.2.1.- Mechanical forms of work 1.2.2.- Thermodynamic definition of work. Forms of quasi static work . 2.2.- ADIABATIC INTERACTION OF WORK. TOTAL ENERGY 2.2.1.- Adiabatic interactions of work. 2.2.2.- Total energy. Postulate III. 2.2.3.- Internal energy. First Law for a closed system. 3.2.- INTERACTIONS OF HEAT. 3.2.1.- Postulate III and non adiabatic work . 3.2.2.- Thermal equilibrium. Postulate IV. 3.2.3.- Postulate IV. Thermometry. Thermometric scales 4.2.- LAWS OF THE GASES. 4.2.1.- Equation of state of ideal gas. 4.2.2.- Mixtures of ideal gases.
3.- STATES AND PROPERTIES OF PURE SUBSTANCES	1.3.- PURE SUBSTANCES. 1.3.1.- Simple Compressible system. 1.3.2.- pVT surface of a pure substance. Projections. 1.3.3.- Thermal Properties. 2.3.-PROPERTY VALUES. 2.3.1.- Tables of properties of pure substances. 2.3.2.- Mixtures of two phases (liquid-vapour). 2.3.3.- Approximations for compressed liquid and model of incompressible substance . 2.3.4.- Real gas. Factor of compressibility. Equations of state Generalised Chart. Law of corresponding states.
4.- THE FIRST LAW FOR OPEN SYSTEMS	1.4.- THE FIRST LAW OF THERMODYNAMICS FOR OPEN SYSTEMS. 1.4.1.- Mass, volume and surface of control. Equation of the First Law. 2.4.2.- Balances of mass and energy in a volume of control. Energy of flow. 3.4.3.- Integral and differential analysis. 3.4.4.- Balances of mass and energy in stationary and no stationary state.

5.- THE SECOND LAW OF THE THERMODYNAMICS	1.5.- ENTROPY AND SECOND LAW. 1.5.1.- Limitations of the First Law. 1.5.2.- Heat Engine. Energetic interactions between two reservoirs. 1.5.3.- Statements of the Second Law. Kelvin-Plank. Clausius. Equivalence of both statements. 1.5.4.- Reversibility. Statement of Carnot. 1.5.5.- Thermodynamic scale of temperature. 1.5.6.- Cycle of Carnot.
6.- ENTROPY AND IRREVERSIBILITY	1.6.- THEOREM OF CLAUSIUS. FUNCTION ENTROPY. 2.6.- ENTROPY 3.6.- PRINCIPLE OF INCREASE OF ENTROPY IRREVERSIBILITY. 3.6.1.- Balance of entropy for an enclosed system. 3.6.2.- Principle of increase of entropy. 4.6.- CHANGE OF ENTROPY. 4.6.1.- Equations Tds. Ideal gas Model. Liquid-vapour mixtures. Hypothesis of constant or variable specific heats. Model of incompressible substance. 5.6.- DIAGRAMS T-s and h-s. Graphic interpretation of the transfer of heat in an internally reversible process. Diagram of Mollier. 6.6.- BALANCE OF ENTROPY FOR CONTROL VOLUME 6.6.1.- Balance of entropy for control volume. Application to stationary and non-stationary flow. 7.6.- WORK IN PROCESSES OF STATIONARY FLOW INTERNALLY REVERSIBLE. 8.6.- ISOENTPROPIC EFFICIENCY 7.6.1.- Turbines. 7.6.2.- Compressors and pumps. 7.6.3.- Nozzles and diffusers.
7.- COMPRESSIBLE FLOW	1.7.- ADIABATIC STAGNATION OF A FLUID 2.7.- SOUND VELOCITY AND MACH NUMBER. 3.7.- EFFECT OF AREA FLOW CHANGES. 4.7.- RELATIONS BETWEEN FLOW PROPERTIES AND MACH NUMBER. 5.7.- EFFECT OF BACK PRESSURE ON NOZZLES.

8.- STEAM AND GAS CYCLES	1.8.- Rankine Cycle, efficiency and improvements. 2.8.- Gas Cycle. 2.8.1.-Otto and Diesel Cycles. 2.8.2.- Brayton Cycle, improvements. Combined Cycle 3.8.- Cycles of refrigeration..
9.- Humid air thermodynamics. Psychrometry	1.9.- Properties. Psychrometric chart. 2.9.- Applications. Air conditioning
10.- REACTIVE MIXTURES. COMBUSTION	1.10.- Combustion, calculations
The previous topics* fulfil with the column 2, "Knowledge, understanding and proficiency", of the Manila amendments to the STCW Code, of the following Table : * The competences acquisition established in Column 1 of the respective STCW Table, are completed with the overcoming of the contents included in the following complementary subjects to this one: Internal Combustion Engines. Steam and Gas Turbines. Heat Transfer and Steam Boilers. Maritime Installations and Propulsion. Automation of Maritime Installations Practical traineeship on board	1.- Table A-III/1 of Specification of minimum standard of competence for officers in charge of an engineering watch in a manned engine-room or designated duty engineers in a periodically unmanned engine-room Function: Marine engineering at operational level Competences -1.1 Maintain a safe engineering watch -1.2 Operate main and auxiliary machinery and associated control systems
The development and overcoming of these contents, together with those corresponding to other subjects that include the acquisition of specific competencies of the degree, guarantees the knowledge, comprehension and sufficiency of the competencies contained in Table AIII / 2, of the STCW Convention, related to the level of management of First Engineer Officer of the Merchant Navy, on ships without power limitation of the main propulsion machinery and Chief Engineer officer of the Merchant Navy up to a maximum of 3000 kW.	Table A-III / 2 of the STCW Convention. Specification of the minimum standard of competence for Chief Engineer Officers and First Engineer Officers on ships powered by main propulsion machinery of 3000 kW or more.

Planning				
Methodologies / tests	Competencies	Ordinary class hours	Student?s personal work hours	Total hours
Introductory activities	B7 B16	2	0	2
Guest lecture / keynote speech	A2 A6 A73 A74 A78 A86 A89 A90 A95 A96 A99 A100 B2 B3 B5 C3 C7	28	42	70
Problem solving	A1 A2 A6 A73 A74 A78 A86 A89 A90 A95 A96 A99 A100 B2 B3 B5 B7 B16 C3 C7	10	24	34

Collaborative learning	A1 A2 A6 A73 A74 A78 A86 A89 A90 A95 A96 A99 A100 B2 B3 B5 B7 B16 C3 C7	5	5	10
Supervised projects	B2 B3 B5 B7 B16 C3 C7	3	15	18
Document analysis	A1 A2 A6 A78 A86 A89 B2 B3 B5 B16 C3	0	4	4
Objective test	A1 A2 A6 A73 A74 A78 A86 A89 A90 A95 A96 A99 A100 B2 B3 B5 B7 B16 C3 C7	4	6	10
Personalized attention		2	0	2
(*)The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.				

Methodologies	
Methodologies	**Description**
Introductory activities	There will be a presentation of the course, emphasizing the importance of this matter as a basis for learning other subjects in the Degree and for professional activities in the field of Marine Engineering. The standards of teaching, qualification and most important bibliographical sources will be set.
Guest lecture / keynote speech	There will be a detailed explanation of the contents of the material, distributed across topics. The student will have a typed copy of the subject matter in each keynote session. Students are encouraged to participate in class, through comments linking the theoretical with real life experiences.
Problem solving	Problems will be solved for each item proposed, allowing the application of mathematical models appropriate to each case, including managing tables, applying the most appropriate assumptions, the theoretical relation developed in lectures and relation with professional practice
Collaborative learning	Problem solving in groups, with the possibility of exposing results.
Supervised projects	Problems more difficult than those solved in class or issues of special relevance.
Document analysis	By means using bibliographical sources of different types, the student will get used to finding information in order to deepen or focus learning from other points of view that are not exclusively those from the professor. It is like a training to the future needs of students in their professional development.
Objective test	There will be a midterm exam so that students become familiar with the type of issues raised in the written tests. It will consist of a theoretical and practical part, so that both computed for 50% of the grade. Regular and special examinations shall be governed by the same format.

Personalized attention	
Methodologies	**Description**

Guest lecture / keynote speech Problem solving Collaborative learning Supervised projects	The personalized attention related with the methodologies that contemplate it, aims to encourage maximum interaction with students, in order to optimize their effort and improve their learning. Through this interaction, together with the other evaluation processes, the degree of learning of the subject competences will be determined, allowing personalized attention to those students who most need it through individualized tutoring, whose convocation will be held in with involved students. Regardless of the face-to-face tutoring programmed by the teacher, the student can go to tutoring, as many times as he wants, and at a time compatible with teaching, research and management professor activities. In accordance with the "norma que regula o réxime de dedicación ao estudo dos estudantes de grao na UDC" (Art.3.b e 4.5) and ""normas de avaliación, revisión e reclamación das cualificacións dos estudos de grao e mestrado universitario? (Art. 3 e 8b), students with part-time recognition and academic exemption from attendance exemption may participate in a personalized and flexible system of mentoring and evaluation tutorials in order to determine the degree of competency learning achieved. Regarding with this matter, the tutorials will serve to carry out those activities included within the methodology of objective tests and problems solution

Assessment			
Methodologies	Competencies	Description	**Qualification**
Guest lecture / keynote speech	A2 A6 A73 A74 A78 A86 A89 A90 A95 A96 A99 A100 B2 B3 B5 C3 C7	Attendance at the sessions will count as part of the final grade. The student must sign a sheet of attendance to every lecture as an evidence for the assessment of this methodology.	5
Problem solving	A1 A2 A6 A73 A74 A78 A86 A89 A90 A95 A96 A99 A100 B2 B3 B5 B7 B16 C3 C7	Ploblem solving with EES (Engineering Equation Solver).	5
Objective test	A1 A2 A6 A73 A74 A78 A86 A89 A90 A95 A96 A99 A100 B2 B3 B5 B7 B16 C3 C7	The student will demonstrate proficiency in the theoretical and practical learning of issues.	70
Supervised projects	B2 B3 B5 B7 B16 C3 C7	Presentation and defense of the work. It will be valued structure, neatness, originality and expository method. This is an optional methodology. For students who don't do the project, the qualification percentage of this methodology will be added to the objective test.	20

Assessment comments

The official tests of the first opportunity, will included the different evaluation methodologies and must be completed by those students who have not passed the continuous evaluation in its entirety. This test will be designed in such a way that the student can examine the problem solving methodologies and objective test, where they have not reached 30% of the total grade.
Students obliged to attend the official "second chance" tests will keep the grade achieved in all methodologies, with the exception of the one obtained in the objective tests of the 1st opportunity, which will be replaced by that of the 2nd. In the same way, you will only be eligible for honors if the maximum number of these for the corresponding course is not covered in its entirety at the "first opportunity".For students with recognition of part-time dedication and academic exemption from attendance, the grade obtained in the activities associated with the personalized tutoring system will correspond to the evaluation of the problem-solving methodology and objective tests, with a weighting of 30 and 70%, respectively.Fraudulent performance of the tests or evaluation activities, once verified, will directly imply a failing grade "0" in the subject and in the corresponding call, besides invalidating any grade obtained in either evaluation activity for the extraordinary call.The evaluation system meets the competency evaluation criteria set out in Column 4 of the following Tables of the STCW Convention, modified by Manila 2010:1.- Table A-III / 1 of Specification of the minimum standards of competence applicable to officers in charge of the watch in a permanently manned engine-room and those appointed to serve in an unmanned engine-room.Function: Naval machinery, at the operational levelCompetencies:-1.1 Carry out a safe machinery watch-1.2 Operate the main and auxiliary machinery and the corresponding control systems.

Sources of information	
Basic	- Moran, M. J. ; Shapiro, H. N (2004). Fundamentos de Termodinámica Técnica . Barcelona.. Reverte - Çengel, Y. A.; Boles, M. A. (2006). Termodinámica. México. McGrawHill - Agüera, J.: (1999). Termodinámica Lógica y Motores Térmicos. Madrid. Ciencia 3. - Rogers, G.; Mayhew, Y. (1992). Engineering Thermodynamics. Work and Heat Transfer. Singapore. Longman
Complementary	- Sonntag, R.; Borgnakke, C (2007). Introduction to engineering thermodynamics.. USA. Wiley - Segura, J. (1990). Termodinámica Técnica. Barcelona. Reverté

Recommendations
Subjects that it is recommended to have taken before
Chemistry/631G03002
Mathematics I/631G03001
Mathematics II/631G03006
Physics I/631G03003
Physics II/631G03008
Subjects that are recommended to be taken simultaneously
Subjects that continue the syllabus
Steam and Gas Turbines/631G02352
Ship Systems Operation with Simulator/631G03043
Cooling Techniques Applied to Ship/631G03024
Internal Combustion Engines/631G03028
Heat Transfer and Steam Generators/631G03022

Other comments

(*)The teaching guide is the document in which the URV publishes the information about all its courses. It is a public document and cannot be modified. Only in exceptional cases can it be revised by the competent agent or duly revised so that it is in line with current legislation.