



## Teaching Guide

Identifying Data					2023/24
Subject (*)	Thermodynamics and Engineering Thermodynamics	Code	631G02254		
Study programme	Grao en Tecnoloxías Mariñas				
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	Baaliña Insua, Alvaro	E-mail	alvaro.baalina@udc.es		
Web	<a href="https://estudios.udc.es/gl/subject/631G02V02/631G02254/2020">https://estudios.udc.es/gl/subject/631G02V02/631G02254/2020</a>				
General description	<p>This subject develops basic concepts for the understanding of the greater part of the processes related with energy in an installation, both on board and ashore.</p> <p>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.</p> <p>To attend the course is advisable to have previous knowledges of Physics and Mathematics.</p>				

## Study programme competences

Code	Study programme competences
A2	CE2 - Capacidade para a dirección, organización e operación das actividades obxecto das instalacións marítimas no ámbito da súa especialidade.
A6	CE6 - Coñecementos e capacidade para a realización de auditorías enerxéticas de instalacións marítimas.
A7	CE7 - Capacidade para a operación e posta en marcha de novas instalacións ou que teñan por obxecto a construción, reforma, reparación, conservación, instalación, montaxe ou explotación, realización de medicións, cálculos, valoracións, taxacións, peritacións, estudos, informes, e outros traballos análogos de instalacións enerxéticas e industriais mariñas, nos seus respectivos casos, tanto con carácter principal como accesorio, sempre que quede comprendido pola súa natureza e característica na técnica propia da titulación, dentro do ámbito da súa especialidade, é dicir, operación e explotación.
A17	CE17 - Modelizar situacións e resolver problemas con técnicas ou ferramentas físico-matemáticas.
A20	CE20 - Ser capaz de identificar, analizar e aplicar os coñecementos adquiridos nas distintas materias do Grao, a unha situación determinada formulando a solución técnica máis axeitada dende o punto de vista económico, ambiental e de seguridade.
A21	CE37 - Capacidad para ejercer como Oficial de Máquinas de la Marina Mercante, una vez superados los requisitos exigidos por la Administración Marítima.
A30	CE42 - Operar, reparar, manter, reformar, optimizar a nivel operacional as instalacións industriais relacionadas coa enxeñaría mariña, como motores alternativos de combustión interna e subsistemas; turbinas de vapor, caldeiras e subsistemas asociados; ciclos combinados; propulsión eléctrica e propulsión con turbinas de gas; equipos eléctricos, electrónicos, e de regulación e control do buque; as instalacións auxiliares do buque, tales como instalacións frigoríficas, sistemas de goberno, instalacións de aire acondicionado, plantas potabilizadoras, separadores de sentinas, grupos electrógenos, etc.
A32	CE44 - Coñecer o balance enerxético xeral, que inclúe o balance termo-eléctrico do buque, ou sistema de mantemento da carga, así como a xestión eficiente da enerxía respectando o medio.
A40	CE47 - Operar a maquinaria principal e auxiliar e os sistemas de control correspondentes.
A44	CE49 - Realizar unha garda de máquinas segura.
A55	Coñecer o balance enerxético xeral, incluíndo o balance termo-eléctrico, así como a xestión eficiente da enerxía respectando o medio.
B2	CT2 - Resolver problemas de forma efectiva.
B7	CT7 - Capacidade para interpretar, seleccionar e valorar conceptos adquiridos noutras disciplinas do ámbito marítimo, mediante fundamentos físico-matemáticos.



C6	C6 - Valorar criticamente o coñecemento, a tecnoloxía e a información dispoñible para resolver os problemas cos que deben enfrontarse.
C10	CB2 - Aplicar os coñecementos no seu traballo ou vocación dunha forma profesional e poseer competencias demostrables por medio da elaboración e defensa de argumentos e resolución de problemas dentro da área dos seus estudos
C11	CB3 - Ter a capacidade de reunir e interpretar datos relevantes para emitir xuízos que inclúan unha reflexión sobre temas relevantes de índole social, científica ou ética

Learning outcomes			
Learning outcomes		Study programme competences	
Analysis and synthesis of the thermodynamic concepts.	A2	B2	C6
Capacity to reason and comprise the energetic interactions in diverse systems.	A6	B7	C10
Capacity to solve energetic and optimisation problems through the concept of entropy and irreversibility.	A7		C11
Planning and decision making regarding the energetic management of industrial installations.	A17		
Critical reasoning about the applicable physical models	A20		
Habit of study and structuring of the information through tables and two-dimensional diagrams of thermodynamic parameters.	A21		
The following competencies included in Table A-III / 1 of the STCW Code as amended by Manila; Function: Marine engineering at operational level	A30		
	A32		
-1.1 Maintain a safe engineering watch	A40		
-1.2 Operate main and auxiliary machinery and associated control systems	A44		
	A55		

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.



<p>2.- WORK, ENERGY AND HEAT.</p>	<p>1.2.- WORK. FORMS OF QUASI STATIC WORK .</p> <p>1.2.1.- Mechanical forms of work 1.2.2.- Thermodynamic definition of work. Forms of quasi static work .</p> <p>2.2.- ADIABATIC INTERACTION OF WORK. TOTAL ENERGY</p> <p>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.</p> <p>3.2.- INTERACTIONS OF HEAT.</p> <p>3.2.1.- Postulate III and non adiabatic work . 3.2.2.- Thermal equilibrium. Postulate IV. 3.2.3.- Postulate IV. Thermometry. Thermometric scales</p> <p>4.2.- LAWS OF THE GASES.</p> <p>4.2.1.- Equation of state of ideal gas. 4.2.2.- Mixtures of ideal gases.</p>
<p>3.- STATES AND PROPERTIES OF PURE SUBSTANCES</p>	<p>1.3.- PURE SUBSTANCES.</p> <p>1.3.1.- Simple Compressible system. 1.3.2.- pVT surface of a pure substance. Projections. 1.3.3.- Thermal Properties.</p> <p>2.3.-PROPERTY VALUES.</p> <p>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.</p> <p>Equations of state Generalised Chart. Law of corresponding states.</p>
<p>4.- THE FIRST LAW FOR OPEN SYSTEMS</p>	<p>1.4.- THE FIRST LAW OF THERMODYNAMICS FOR OPEN SYSTEMS.</p> <p>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.</p> <p>3.4.3.- Integral and differential analysis. 3.4.4.- Balances of mass and energy in stationary and no stationary state.</p>



<p>5.- THE SECOND LAW OF THE THERMODYNAMICS</p>	<p>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.</p>
<p>6.- ENTROPY AND IRREVERSIBILITY</p>	<p>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.- ISOENTROPIC EFFICIENCY 7.6.1.- Turbines. 7.6.2.- Compressors and pumps. 7.6.3.- Nozzles and diffusers.</p>
<p>7.- COMPRESSIBLE FLOW</p>	<p>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.</p>



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, &quot;Knowledge, understanding and proficiency&quot;, 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	C6	2	0	2
Guest lecture / keynote speech	A2 A6 A7 A17 A20 A21 A32 A40 A44 A55 B2 B7 C6	28	42	70
Problem solving	A6 A7 A17 A20 A21 A32 A40 A44 A55 B2 B7 C6	10	24	34
Collaborative learning	A2 A6 A20 A40 A44 B2 B7 C6 C10 C11	5	5	10
Supervised projects	A2 A6 A7 A17 A20 A21 A30 A32 A55 B2 B7 C6 C10 C11	3	15	18



Document analysis	A20 B7 C6 C10 C11	0	4	4
Objective test	A2 A6 A7 A17 A20 A21 A30 A32 A40 A44 A55 B2 B7 C6 C10 C11	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
Problem solving Guest lecture / keynote speech 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



Problem solving	A6 A7 A17 A20 A21 A32 A40 A44 A55 B2 B7 C6	Problem solving with EES (Engineering Equation Solver).	5
Guest lecture / keynote speech	A2 A6 A7 A17 A20 A21 A32 A40 A44 A55 B2 B7 C6	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
Objective test	A2 A6 A7 A17 A20 A21 A30 A32 A40 A44 A55 B2 B7 C6 C10 C11	The student will demonstrate proficiency in the theoretical and practical learning of issues.	70
Supervised projects	A2 A6 A7 A17 A20 A21 A30 A32 A55 B2 B7 C6 C10 C11	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 "fail" (numeric mark 0) in the subject and in the corresponding first or second call, besides invalidating any grade obtained in either evaluation activity for the extraordinary call. For that, the mark in the first chance will be modified if needed. 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 level

Competencies:-1.1 Carry out a safe machinery watch-1.2 Operate the main and auxiliary machinery and the corresponding control systems.

**Sources of information**

<b>Basic</b>	<ul style="list-style-type: none"> <li>- Moran, M. J. ; Shapiro, H. N (2004). Fundamentos de Termodinámica Técnica . Barcelona.. Reverte</li> <li>- Çengel, Y. A.; Boles, M. A. (2006). Termodinámica. México. McGrawHill</li> <li>- Agüera, J.: (1999). Termodinámica Lógica y Motores Térmicos. Madrid. Ciencia 3.</li> <li>- Rogers, G.; Mayhew, Y. (1992). Engineering Thermodynamics. Work and Heat Transfer. Singapore. Longman</li> </ul>
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<b>Complementary</b>	- Sonntag, R.; Borgnakke, C (2007). Introduction to engineering thermodynamics.. USA. Wiley - Segura, J. (1990). Termodinámica Técnica. Barcelona. Reverté
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## Recommendations

### Subjects that it is recommended to have taken before

Mathematics I/631G02151  
Physics I/631G02153  
Mathematics II/631G02156  
Chemistry/631G02157  
Physics II/631G02158

### Subjects that are recommended to be taken simultaneously

### Subjects that continue the syllabus

Internal Combustion Engines/631G02351  
Steam and Gas Turbines/631G02352  
Air Conditioning and Cooling Techniques/631G02355  
Thermal Marine Machinery/631G02361

### 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.