UNIVERSITÀ DEGLI STUDI DI PALERMO

DEPARTMENT	Ingegneria
ACADEMIC YEAR	2022/2023
BACHELOR'S DEGREE (BSC)	ENERGY ENGINEERING AND RENEWABLE ENERGIES
SUBJECT	ENERGETICS
TYPE OF EDUCATIONAL ACTIVITY	B
AMBIT	50299-Ingegneria energetica
CODE	03003
SCIENTIFIC SECTOR(S)	ING-IND/10
HEAD PROFESSOR(S)	CATRINI PIETRO — Ricercatore a tempo determinato — Univ. di PALERMO
OTHER PROFESSOR(S)	
CREDITS	6
INDIVIDUAL STUDY (Hrs)	96
COURSE ACTIVITY (Hrs)	54
PROPAEDEUTICAL SUBJECTS	
MUTUALIZATION	
YEAR	2
TERM (SEMESTER)	2° semester
ATTENDANCE	Not mandatory
EVALUATION	Out of 30
TEACHER OFFICE HOURS	**CATRINI PIETRO** Monday 12:00 13:00 Stanza T103, Edificio 9. Tuesday 12:00 13:00 Stanza T103, Edificio 9. Wednesday 12:00 13:00 Stanza T103, Edificio 9. Thursday 12:00 13:00 Stanza T103, Edificio 9. Friday 12:00 13:00 Stanza T103, Edificio 9.

DOCENTE: Prof. PIETRO CATRINI

PREREQUISITES	Basic knowledge of Thermodynamics, Heat Transfer, Psychrometrics, Fluid Mechanics, Chemistry, and Applied Chemistry.
LEARNING OUTCOMES	Knowledge and understanding The student, at the end of the course, will acquire specific knowledge to deal with the basic aspects of the energy processes involved in civil and industrial installations. In addition, he will acquire knowledge about the functioning of energy systems. The verification happens during the oral exam. Applying knowledge and understanding The student, at the end of the course, will have acquired knowledge and understanding of appropriate capacity and professionalizing about the characterization of energy systems and industrial processes, being able to evaluate the performance and its efficiency to address the various issues relating to the use efficiency. Furthermore, the student will also be able to develop thermodynamic models describing the energy transformations occurring in energy systems and industrial processes. The oral exam is the verification tool. Making judgments The student, at the end of the course, will have acquired an adequate judgment in relation to the main issues about teaching, having gained the ability to derive the necessary data autonomously. The verification happens during the oral exam. Communication skills The student will be able to communicate to others with skill and formal properties of language in relation to the issues of teaching relevance. The oral exam is the verification tool. Learning ability The student will be able to face the problems relating to the autonomy of teaching relevant topics for a continuation in the study and profession. The verification happens during the oral exam.
ASSESSMENT METHODS	The assessment is done by an oral examination on the following areas: Energy Analysis, Power systems, Energy Conversion Systems. The oral exam consists of 3 open questions (duration 1 h max). The aim of the tests is to verify the acquired knowledge and the ability to critique, processing and communication skills. The final vote is out of thirty, eventually cum laude. A) Excellent (30-30 cum laude): Excellent knowledge of teaching contents; students should show high analytical and synthetic capabilities and should be able to apply their knowledge to solve highly complex problems. B) Very good (27-29): Very good knowledge of the teaching contents and excellent language control; students should show analytical and synthetic skills and be able to apply their knowledge to solve problems of medium and, in some cases, even higher complexity. C) Good (24- 26): Good knowledge of teaching contents and good language control; the students should be able to apply their knowledge to solve problems of medium complexity D) Satisfactory (19-23): Average knowledge of the teaching contents, in some cases limited to the main topic; acceptable ability to use the specific discipline language and independently apply the acquired knowledge. E) Sufficient (18): Minimum teaching content knowledge, often limited to the main topic; modest ability to use the subject-specific language and independently apply the acquired knowledge. F) Fail (less than 18): Lack of acceptable knowledge of the main teaching content knowledge. Very little or no ability to use the specific subject language and apply independently the acquired knowledge
EDUCATIONAL OBJECTIVES	The course aims to provide the basics of energy and exergetic analysis for the optimization of energy components and systems, both traditional and innovative. It also aims to provide an overview of the various thermodynamic cycles used in the field of power generation and refrigeration.
TEACHING METHODS	Teaching is organized in theoretical lectures and practical exercises. The exercises are numerical drills solved in the classroom by the teacher. The drills are based on the theoretical concepts introduced in class and related to typical energy applications both civil and industrial.
SUGGESTED BIBLIOGRAPHY	Testi di riferimento/Textbook 1. Dispense del Docente, articoli e manuali distribuiti durante il corso. 2. T.J. Kotas, "The Exergy Method of Thermal Plant Analysis", Paragon Publishing, 2012, EAN: 9781908341891. 3. Cucumo MA, Kaliakatsos D, Marinelli V, “Energetica”, Pitagora Ed., 2006,

	ISBN 88-371-1625-X. 3. G. Lozza, "Turbine a Gas e Cicli Combinati", Esculapio Editore, 2020, ISBN 978-88-7488-934-1. 4. O. Acton, C. Caputo, "Impianti Motori", UTET, 1992, ISBN 88-02-04668-9. Testi di utile consultazione/Useful books 1.F. Calise, M. Dentice D'Accadia, L. Vanoli, R. Vanoli, "Fondamenti di analisi exergetica", Giapeto Editore, Napoli, 2018, ISBN-10:8893260638, ISBN-13:978-8893260633 2. Negri Di Montenegro G, et al.: "Sistemi energetici e macchine a fluido" Vol. 1, Pitagora Ed. Bologna, 2009, ISBN 88-371-1761-2 3. Bianchi M, et al.: "Sistemi energetici - Complementi" Vol. 2, Pitagora Ed. Bologna, 2008, ISBN 88-371-1755-8 4. Bianchi M, et al.: "Sistemi energetici - Impatto ambientale" Vol. 3, Pitagora Ed. Bologna, 2008, ISBN 88-371-1754-X 5. Bejan A, Tsatsaronis G, Moran M: "Thermal design and optimization", J. Wiley, 1996, ISBN: 978-0-471-58467-4 6. Eastop TD, McConkey A, "Applied Thermodynamics for Engineering Technologists", 5th Ed., Pearson-Prentice Hall, 1993, ISBN-10: 9780582091931, ISBN-13: 978-05820919315. 7. Kirillin VA, Sycev VV, Seyndlin AE: "Termodinamica Tecnica", Ed. Riuniti/ MIR, 1980, ISBN-10: 8835920795ISBN-13: 978-8835920793. 8. Kreith F, "Principles of Sustainable Energy Systems" 2nd Ed., CRC Press, 2013, ISBN-10: 9781466556966, ISBN-13:978-1466556966

SYLLABUS

Hrs	Frontal teaching
2	Introduction to the course. Recalls of Technical Physics.
4	Entropy analysis of components and energy systems. Gouy-Stodola theorem for calculating loss of work capacity and minimum "restoring" work. Application to the case of heat transfer, uncontrolled expansion, and mixing of fluids at different temperatures.
10	Exergy: analysis of the definition and properties. Exergy of heat flows, of work. Exergy of heat flows and work. Exergy of a stream of matter (analysis of the kinetic, gravitational, physical, and chemical components). Exergetic balance for open systems operating at steady state. Energy and exergetic analysis of components (Turbomachines, Valves, Heat Exchangers, and Boilers). Calculation of the exergetic content of fuels. Exergetic analysis of direct and inverse thermodynamic cycles. Exergetic analysis of cooling and heating processes. Description of Grassmann-Sankey diagram. Notes to the calculation of the exergetic content of closed systems
6	Direct Steam Cycles. Methods for increasing the thermodynamic efficiency. Mass and energy balance for the regenerative Rankine cycle. Description of the main plant components: boiler, turbines, pumps, regenerative exchangers (open and closed type), degasser, condenser, and evaporative towers. Analysis of the typical layout of a steam cycle for a thermoelectric power plant. Difference between subcritical and hypercritical cycles.
6	Analysis of the ideal Brayton-Joule cycle. Calculation of work output and thermodynamic efficiency. Analysis of the effect of the cycle pressure ratio on work output and efficiency. Analysis of the deviations of the real cycle from the ideal one. Regenerative ideal Brayton-Joule cycle. Ericsson cycle. Intercooling and Post-combustion: choice of optimal pressure, effects on work output and thermodynamic efficiency. Components description of turbogas plants. Notes on STIG and ISTIG plants.
3	Notes on Binary Direct Steam Cycles. Combined Gas-Steam Cycles: development of the thermodynamic model. Description of the Heat Recovery Steam Generator. Notes on cogeneration.
4	Absorption refrigeration machines. Description of thermodynamic transformations and main components. Pressure-temperature diagrams. Description of the properties of the couples "Water-Lithium-Bromide" and "Ammonia-Water". Derivation of COP and analysis of typical COP values for machines on the market. Differences between "directly fired" and "undirectly fired" machines. Rational use of absorption chillers and comparison with vapor compression chillers. Operation of absorption machines in "heat pump" and "heat transformer" mode. Description of energy flows exchanged to/from absorption machines.
4	Advanced Refrigeration Cycles: multi-stage cycles and cascade cycles. Linde-Hampson Liquefaction Cycle.

Hrs	Practice
3	Numerical applications on Entropic Balance and Gouy-Stodola Theorem.
5	Numerical applications on exergetic analysis of components and plants.
2	Numerical application on the regenerative Rankine cycle.
4	Numerical Applications on the Brayton-Joule Cycle.
1	Numerical application on combined gas-steam cycle.