UNIVERSITÀ DEGLI STUDI DI PALERMO

DEPARTMENT	Ingegneria		
ACADEMIC YEAR	2022/2023		
BACHELOR'S DEGREE (BSC)	ENERGY ENGINEERING AND RENEWABLE ENERGIES		
INTEGRATED COURSE	ENERGETICS AND FLUID MACHINES		
CODE	18191		
MODULES	Yes		
NUMBER OF MODULES	2		
SCIENTIFIC SECTOR(S)	ING-IND/10, ING-IND/08		
HEAD PROFESSOR(S)	BECCARI STEFANO	Professore Associato	Univ. di PALERMO
OTHER PROFESSOR(S)	BECCARI STEFANO CATRINI PIETRO	Professore Associato Ricercatore a tempo determinato	Univ. di PALERMO Univ. di PALERMO
CREDITS	12		
PROPAEDEUTICAL SUBJECTS			
MUTUALIZATION			
YEAR	2		
TERM (SEMESTER)	2° semester		
ATTENDANCE	Not mandatory		
EVALUATION	Out of 30		
TEACHER OFFICE HOURS	**BECCARI STEFANO** Monday 15:00 19:00 Ufficio docente **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. STEFANO BECCARI

PREREQUISITES	Basic knowledge of: Chemistry and Applied Chemistry, Technical Drawing, Electrotechnology, Fluid Dynamics, Thermodynamics, Heat Transfer.
LEARNING OUTCOMES	Knowledge and understanding The student, at the end of the course, will acquire specific knowledges to deal with the basic aspects of the energy processes involved in civil and industrial installations. In addition, he will acquire knowledges about the functioning of fluid machines and their application in energy systems. The verification happens during the written/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 machines, systems and industrial processes, being able to evaluate the performance and its efficiency to address the various issues relating to the use efficiency. The student will be able to select one of the several kinds of fluid machines, identifying the most appropriate solution for each case. The written/oral exam is the verification tool. Making judgments The student, at the end of the course, will have acquired adequate judgment in relation to the main issues about to teaching, having gained the ability to derive the necessary data autonomously. The verification happens during the written/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 written/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 written/oral exam.
ASSESSMENT METHODS	The assessment is done by an oral examination on the following areas: Energy Analysis, Power systems, Energy Conversion Systems. Fluid Machines: general characteristics, turbomachinery, volumetric machines. The written tests consist in the commented resolution of some questions and/or numeric or theoretical exercises, also with the use of informatic devices (duration 3 h max) per module. The oral exam consists of 2 ÷ 3 open questions (duration 30 min max) per module. 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 an 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.
TEACHING METHODS	Teaching is organized in theoretical lectures and practical exercises. The exercises are numerical drills solved in the classroom by the teacher and / or students under the guidance of professor. The drills are based on the theoretical concepts introduced in class and related to typical energy applications both civil and industrial.

MODULE
ENERGETICS

Prof. PIETRO CATRINI

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

AMBIT	50299-Ingegneria energetica
INDIVIDUAL STUDY (Hrs)	96
COURSE ACTIVITY (Hrs)	54

EDUCATIONAL OBJECTIVES OF THE MODULE

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.

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.

MODULE
PROCESS MACHINERY

Prof. STEFANO BECCARI

SUGGESTED BIBLIOGRAPHY

Testi di utile consultazione/Useful books
1. Dispense del Docente, distribuite durante il corso.
2. Beccari Alberto, “Macchine”, CLUT Editore, 1993, ISBN: 9788879920339
3. Beccari Alberto, "Esercizi di macchine", CLUT Editore, 1986, ISBN: 9788879920438
4. G. Cornetti “Macchine termiche”, Ed. Il Capitello, Torino, 1994, ISBN: 9788842672883
5. G. Cornetti “Macchine idrauliche”, Ed. Il Capitello, Torino, 1994, ISBN: 9788842672876

AMBIT	50299-Ingegneria energetica
INDIVIDUAL STUDY (Hrs)	96
COURSE ACTIVITY (Hrs)	54

EDUCATIONAL OBJECTIVES OF THE MODULE

The course aims to provide the fundamental notions on the design criteria, on the operation and on the choice of fluid machines, turbo and volumetric, based on their efficiency and performance.

SYLLABUS

Hrs	Frontal teaching
9	Introduction to the study of machines: machine classification (turbo, volumetric, alternative, rotary, axial, centrifugal); open and closed systems; Lagrangian and Eulerian point of view; 1st Principle of Thermodynamics: Lagrangian expression, Eulerian expression, permanent motion; 2nd Principle of Thermodynamics, work of passive resistances; polytropic evolutions; perfect gas; representation diagrams: Gibbs plane (T, s), Mollier plane (i, s), Clapeyron plane (p, v); hydraulic and internal efficiency; total quantities; isentropic arrest.
9	Turbopumps: Recalls of formulas, Bernoulli's theorem; manometric characteristic of the pump; prevalence; coupling to the external circuit: operating point and stability; pump regulation: throttling on delivery, variation of angular speed, backflow; starting and starting problems; cavitation and maximum installation height; pumps in parallel and in series: calculation of the equivalent characteristic; equations for the calculation of similitude operation. Ulteriori informazioni su questo testo di originePer avere ulteriori informazioni sulla traduzione è necessario il testo di origine Invia commenti Riquadri laterali
9	Hydraulic turbines: Hydraulic motor systems for the production of electricity: main elements of the system (delivery duct, regulation organs, turbine, alternator); characteristic efficiency of the plant and achievable powers; the types of hydraulic turbines and their classification: speed triangles; efficiency and power; operating characteristics and regulation curves, similarity of operation, choice of machine and Balje diagram.
9	Turbochargers: internal work and variation of the angular momentum: Euler equation; centrifugal and axial turbocharger: triangles of speed, work and reaction rate; centrifugal turbocharger: manometric characteristic; speed triangles; axial turbocharger; triangles of speed and reaction rate; similarity of operation, operation maps and choice of the machine. operating point of a turbocharger and stability; adjustment of a turbocharger: intlet duct lamination, outlet duct lamination, by-pass, variation of the rotation speed, variation of the pitch angle of the diffuser and impeller blades.
9	Steam turbines: Compressible fluid turbines: triangles of the velocities of action and reaction axial stages; optimal operating conditions in the ideal case and in the real case (dissipations due to fluid dynamic friction); efficiency and power.
9	Internal combustion engines: reference thermodynamic cycles (Otto, Diesel), indicated cycle and indicated mean effective pressure, engine efficiency and specific fuel consumption, volumetric efficiency, brake mean effective pressure and engine power, supercharging, operating characteristics curves.