



# UNIVERSITÀ DEGLI STUDI DI PALERMO

<b>DEPARTMENT</b>	Ingegneria
<b>ACADEMIC YEAR</b>	2024/2025
<b>MASTER'S DEGREE (MSC)</b>	ENERGETIC AND NUCLEAR ENGINEERING
<b>SUBJECT</b>	ANALYSIS OF ENERGY SYSTEMS AND THERMAL ECONOMICS
<b>TYPE OF EDUCATIONAL ACTIVITY</b>	B
<b>AMBIT</b>	50367-Ingegneria energetica e nucleare
<b>CODE</b>	18021
<b>SCIENTIFIC SECTOR(S)</b>	ING-IND/10
<b>HEAD PROFESSOR(S)</b>	PIACENTINO ANTONIO Professore Ordinario Univ. di PALERMO
<b>OTHER PROFESSOR(S)</b>	
<b>CREDITS</b>	6
<b>INDIVIDUAL STUDY (Hrs)</b>	96
<b>COURSE ACTIVITY (Hrs)</b>	54
<b>PROPAEDEUTICAL SUBJECTS</b>	
<b>MUTUALIZATION</b>	
<b>YEAR</b>	1
<b>TERM (SEMESTER)</b>	1° semester
<b>ATTENDANCE</b>	Not mandatory
<b>EVALUATION</b>	Out of 30
<b>TEACHER OFFICE HOURS</b>	<b>PIACENTINO ANTONIO</b> Monday 11:30 13:30 Stanza T121 - 1° piano Edificio n 9, Dipartimento di Ingegneria

<p><b>PREREQUISITES</b></p>	<p>The student should have some basic knowledge about the fundamentals of thermodynamics and heat transfer and their main applicative aspects.</p>
<p><b>LEARNING OUTCOMES</b></p>	<p>Knowledge and capability to understand: At the end of the course, the student will have acquired an in-depth knowledge of the principles of analysis and optimization of energy systems, process integration and thermoeconomics.</p> <p>Applying knowledge and understanding: The student will be able to perform energetic, economic and elementary thermoeconomic analysis for simplified energy systems (such as power plants and refrigeration) and for single components. Also, the student will be able to identify margins for energy savings in energy-intensive industries by process integration.</p> <p>Autonomous evaluation: The student will be able to identify, in full autonomy and with no need of external support, the main critical issues concerning the efficiency of energy conversion processes. Also, he/she will be able to perform autonomous analyses oriented to cost minimization.</p> <p>Capabilities to explain: The student will be able to discuss retrofit options with both technical experts and management engineers, due to the acquisition of both an in-dept understanding of the margins for thermodynamic/economic improvement and of the appropriate technical nomenclature in the field.</p> <p>Lifelong learning skills The student will develop a solid knowledge on the applicative potential of principles of Thermodynamics and Thermoeconomic analysis, and will be consequently mature to further consolidate a) on field its capability to optimize systems, after acquiring understanding of specific industrial processes and b) on advanced theoretical course focused on the optimization of design of thermal equipments by more sophisticate techniques .</p>
<p><b>ASSESSMENT METHODS</b></p>	<p>The evaluation is based on a final oral examination. The student must meet, during the oral examination, at least three open more specific questions on all the contents covered by the course, according to approaches available in the support material or the recommended textbooks. During the examination, the student may be asked to solve a computer-aided analysis of energy systems, so as to assess its capability to address practical case studies similar to those developed during the lessons in class. The final assessment is aimed at evaluating the student in terms of knowledge and level of understanding of the topics addressed in the course, capability of interpretation and autonomous analysis of applicative case studies. In order to achieve a sufficient evaluation, the student must at least show knowledge and understanding of general issues and some basic applicative skills in thermodynamic and thermoeconomic analysis of energy systems; at meantime, the student must expose sufficient capabilities in discussing and argumenting the topics, demonstraing the possibility to transfer his knowledge to the examiner. Below this threshold, the examination is considered not sufficient. The duration of the oral examination is approximately 40 minutes. The evaluation marks are out of thirty.</p> <p>Rating - Votes Excellent 30 - 30 with distinction: excellent knowledge and understanding of the topics, excellent evidence of capability to apply the theoretical and technical knowledge for solving problems, excellent ability to communicate knowledge in terms of clearness, fluency and correct use of language Very good 26-29: very good knowledge and understanding of the topics, evidence of more than adequate capability to apply the theoretical and technical knowledge for solving problems, very good ability to communicate knowledge with clearness and appropriate use of language Good 24-25: basic knowledge of the main topics, good capability to explain concept with a good use of technical language, reasonable ability to independently apply the knowledge to the solution of the proposed problems Satisfactory 21-23: student does not have full capabilities but has the basic knowledge, more than sufficient control of the technical language, more than sufficient ability to address autonomously practical problems by applying the theroretical knowledge Sufficient 18-20: student has minimal knowledge of topics and minimal capability to use the appropriate language, very little ability to independently apply the knowledge Insufficient: student does not have an acceptable knowledge of the topics.</p>

	Compensatory tools and dispensatory measures will be guaranteed by the Disability and Neurodiversity Center - University of Palermo (Ce.N.Dis.) to students with disabilities and neurodiversity, based on specific needs and in implementation of current legislation.
<b>EDUCATIONAL OBJECTIVES</b>	The course is aimed at providing an in-depth knowledge and understanding of the principles of advanced energetics, process integration and thermoeconomics, thus enabling the student to perform analysis and optimization for simple and complex energy systems. Also, the course is aimed at making the students to acquire some basic capabilities with specialistic software for the simulation and optimization of energy systems; the practical exercises are thus intended to ensure that the students are able to apply the principles learned to real world applications.
<b>TEACHING METHODS</b>	Lessons and numerical applications.
<b>SUGGESTED BIBLIOGRAPHY</b>	* A. Piacentino: Note, slides e scripts di software messi a disposizione dal Docente.  Altri testi per approfondimento: * I. Kemp: Pinch Analysis and Process Integration, 2nd Edition. Butterworth-Heinemann, Elsevier, 2007, Print ISBN: 9780750682602, ebook ISBN: 9780080468266. * F-Chart: Engineering Equation Solver Manual (free pdf available online), no ISBN available.

## SYLLABUS

Hrs	Frontal teaching
5	Fundamentals of economics for engineers: cash flows for interventions in the energy sector, differential cash flows, inflation and interest rates, constant and variable currency analyses, Net Present Value, Simple and Discounted Payback Time, Internal Rate of Return, Loans repayment
5	Optimization of energy systems: synthesis, design and operation. Multi-objective optimization, Pareto optimal frontier and approaches to obtain it.
4	Modelling of CHP gas turbine system with heat recovery, and computer-aided optimization of the reference case study often indicated as "CGAM problem".
10	Energetic analysis and modelling of thermal desalination processes: fundamentals of Multiple Effect Evaporation systems- CHP retrofit for MED plants - Basic elements of assessment criteria as "high efficiency cogeneration" for units characterized by null or non-null "beta factor"
10	Process integration and heat exchangers networks: data extraction, composite curves, Table Problem method and Grand Composite curve, golden rules of pinch analysis and design of the Maximum Energy Recovery (MER) network, brief notes on multiple targeting (area- and number of heat exchangers- based), simplified modelling of heat exchangers, notes on the mass and water recovery networks
3	Fundamentals of Thermoeconomics: costs and exergy-costing, energy- vs. exergy-based cost accounting, levels of aggregation in plant modelling
5	Theory of the Exergetic cost, Symbolic exergoeconomics, Fuel-Product-Residue representation of energy systems, Productive Structure, Principle of non-equivalence of irreversibilities,
2	Thermoeconomic diagnosis of malfunctions: Fuel-Impact formula, examples for the gas turbine plant.
Hrs	Practice
2	Computer-aided determination of the Pareto front for a cogeneration system.
3	Computer-aided energy analysis for a dual purpose "power + desalted water" plant
3	Application of process integration to the synthesis of a simple heat exchangers network
2	Application of simple exergoeconomics, Theory of Exergetic Cost and Symbolic exergoeconomics to a steam cycle