UNIVERSITÀ DEGLI STUDI DI PALERMO

DEPARTMENT	Ingegneria
ACADEMIC YEAR	2018/2019
MASTER'S DEGREE (MSC)	ENERGETIC AND NUCLEAR ENGINEERING
SUBJECT	ANALYSIS OF ENERGY SYSTEMS AND THERMAL ECONOMICS
TYPE OF EDUCATIONAL ACTIVITY	B
AMBIT	50367-Ingegneria energetica e nucleare
CODE	18021
SCIENTIFIC SECTOR(S)	ING-IND/10
HEAD PROFESSOR(S)	PIACENTINO ANTONIO Professore Ordinario Univ. di PALERMO
OTHER PROFESSOR(S)	
CREDITS	9
INDIVIDUAL STUDY (Hrs)	144
COURSE ACTIVITY (Hrs)	81
PROPAEDEUTICAL SUBJECTS	
MUTUALIZATION	
YEAR	1
TERM (SEMESTER)	1° semester
ATTENDANCE	Not mandatory
EVALUATION	Out of 30
TEACHER OFFICE HOURS	**PIACENTINO ANTONIO** Monday 11:30 13:30 Stanza T121 - 1° piano Edificio n 9, Dipartimento di Ingegneria

DOCENTE: Prof. ANTONIO PIACENTINO

PREREQUISITES	The student should have some basic knowledge about the fundamentals of thermodynamics and heat transfer and their main applicative aspects.
LEARNING OUTCOMES	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, exergy analysis, process integration and thermoeconomics. Applying knowledge and undertanding: The student will be able to perform energetic, exergetic, 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. 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. 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. Lifelong learning skills The student will develop a solid knowledge on the applicative potential of II Principle and Thermoeconomic analysis, and will be consequently mature to further consolidate a) on field its capability to optimize systems, after acquiring understandingof specific industrial processes and b) on advanced theoretical course focused on the optimization of design of thermal equipments by sophisticate techniques like “entropy generation minimization” or “Design of Experiments (DoE)”.
ASSESSMENT METHODS	The evaluation is based on a final oral examination. The student must meet, during the oral examiantion, 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. 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
EDUCATIONAL OBJECTIVES	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.
TEACHING METHODS	Lessons and numerical applications.
SUGGESTED BIBLIOGRAPHY	* A. Piacentino: Note, slides e scripts di software messi a disposizione dal Docente. Altri testi per approfondimento: * A. Bejan: Advanced Engineering Thermodynamics, 3rd Edition. Wiley, 2006 * I. Kemp: Pinch Analysis and Process Integration, 2nd Edition. Butterworth-Heinemann, Elsevier, 2007.

SYLLABUS

Hrs	Frontal teaching
6	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
8	Optimization of energy systems: synthesis, design and operation. Design and operation variables, constraints, objective functions. Multi-objective optimization, Pareto optimal frontier and approaches to obtain it, elements of Mathematical Programming
12	Fundamentals of exergy analysis: exergy of flow systems and heat flows, generalized exergy analysis, application to power plants (with detailed analysis for steam cycles), refrigeration systems, thermal separation processes (example: seawater desalination) and minimum theoretical work of separation, mixtures of air and water vapor (air-conditioning applications)
6	Energetic analysis and modelling of thermal desalination processes: fundamentals of Multiple Effect Evaporation systems- CHP retrofit for MED plants and basic elements for the assessment as "high efficiency cogeneration" of units characterized by "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
6	Fundamentals of Thermoeconomics: costs and exergy-costing, energy- vs. exergy-based cost accounting, levels of aggregation in plant modelling
14	Theory of the Exergetic cost, Symbolic exergoeconomics, Fuel-Product-Residue representation of energy systems, Productive Structure, Principle of non-equivalence of irreversibilities,
4	Thermoeconomic diagnosis of malfunctions: examples for the gas turbine plant and perspectives for refrigeration systems

Hrs	Practice
5	Computer-aided optimization of the so-called CGAM plant – Computer-aided determination of the Pareto front for a cogeneration system – Simple trade off analysis for inverse cycles
3	Computer-aided energetic and exergetic analysis for a dual purpose “power + desalted water” plant
3	Application of process integration to the synthesis of a simple heat exchangers network
4	Application of simple exergoeconomics, Theory of Exergetic Cost and Symbolic exergoeconomics to a steam cycle