COURSE OUTLINE (1)

GENERAL

SCHOOL	**Engineering**		
ACADEMIC UNIT	Mechanical Engineering		
LEVEL OF STUDIES	Undergraduate		
COURSE CODE	EN3400	**SEMESTER**	9th
COURSE TITLE	Thermal Systems Design		

INDEPENDENT TEACHING ACTIVITIES *if credits are awarded for separate components of the course, e.g. lectures, laboratory exercises, etc. If the credits are awarded for the whole of the course, give the weekly teaching hours and the total credits*	**WEEKLY TEACHING HOURS**	**CREDITS**
Lectures and practice exercises	5	6
Add rows if necessary. The organisation of teaching and the teaching methods used are described in detail at (d).		

COURSE TYPE *general background, special background, specialized general knowledge, skills development*	Special background, specialized general knowledge, skills development
PREREQUISITE COURSES:	There are no prerequisite courses. It is recommended that students who are interested in attending the course have completed successfully the following courses: Thermodynamics I & II, Turbomachinery, Operations Management.
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	Greek
IS THE COURSE OFFERED TO ERASMUS STUDENTS	No
COURSE WEBSITE (URL)	https://www.mie.uth.gr/?page_id=18501&lang=en

(2) LEARNING OUTCOMES

Learning outcomes

The course learning outcomes, specific knowledge, skills and competences of an appropriate level, which the students will acquire with the successful completion of the course are described.

Consult Appendix A

- *Description of the level of learning outcomes for each qualifications cycle, according to the Qualifications Framework of the European Higher Education Area*
- *Descriptors for Levels 6, 7 & 8 of the European Qualifications Framework for Lifelong Learning and Appendix B*
- *Guidelines for writing Learning Outcomes*

This course aims to supply the undergraduate students with all the appropriate knowledge and skills that will allow them to understand the modelling principles of energy systems, as well as of their design modeling and optimization. The course is based on the exploitation of previously acquired knowledge by the students during core subjects of the earlier semesters. The main objective of the course is a student to be able to integrate this knowledge in practical engineering applications.

Initially, the characteristics of energy systems design are presented and also define the workable, optimal, and near optimal design. Then methods and tools used in the design of energy systems are mentioned and a short presentation of computational tools and software, both specialized in the field and more general ones, is made. A significant part is devoted in an overview of the thermodynamic principles and definitions as well as in their application in a characteristic example of energy production. For the latter, it has been selected a cogeneration steam-energy system for the fulfilment of a factory's specific needs. This example is presented, used and evolved during the whole duration of the semester and the presented theories and techniques are applied on it. Moreover, the modeling and design of piping systems is mentioned. The core of the energy systems design approach is the exergy analysis which is presented in detail before the introduction of the economic analysis. The combination of the two methods (exergy and economic analysis) leads naturally to the next section of thermoeconomic analysis and evaluation of a system. Finally, thermoeconomic optimization techniques are mentioned with special emphasis to the optimization of heat exchanger networks as well as in the application of optimization techniques in the cogeneration system.

With the successful completion of this course the student will be able to:

- Apply their previous knowledge in engineering problems
- Apply the design techniques of energy systems
- Know the steps to compose and write a technical report and a feasibility study
- Apply the exergy analysis of energy systems and also evaluate them based on the results
- Know the principles of economic evaluation
- Estimate the total capital investment of an energy system
- Calculate the revenue requirements
- Know the tools of economic and technical analysis and evaluation
- Use optimization techniques in heat exchanger networks
- Know the general design optimization techniques for energy systems

General Competences

Taking into consideration the general competences that the degree-holder must acquire (as these appear in the Diploma Supplement and appear below), at which of the following does the course aim?

Search for, analysis and synthesis of data and information, with the use of the necessary technology	*Project planning and management*
Adapting to new situations	*Respect for difference and multiculturalism*
Decision-making	*Respect for the natural environment*
Working independently	*Showing social, professional and ethical responsibility and sensitivity to gender issues*
Team work	*Criticism and self-criticism*
Working in an international environment	*Production of free, creative and inductive thinking*
Working in an interdisciplinary environment	……
Production of new research ideas	*Others…*
	…….

- Search for, analysis and synthesis of data and information, with the use of the necessary technology
- Decision-making
- Working independently
- Project planning and management
- Respect for the natural environment
- Production of free, creative and inductive thought

(3) **SYLLABUS**

1. Workable, optimal and near optimal design. Methods of designing energy systems
2. Basic thermodynamic principles and definitions. The control volume.
3. Reactive mixtures and combustion. Thermodynamic modeling of the cogeneration system.
4. Modeling and design of piping system
5. Exergy, physical exergy, exergy balance, chemical exergy
6. Guidelines for evaluating and improving thermodynamic effectiveness
7. Estimation of total capital investment
8. Principles of economic evaluation. Levelized costs and cost of the main product
9. Fundamentals of thermoeconomics
10. Thermoeconomic variables for component evaluation. Thermoeconomic evaluation
11. Cost-Optimal exergetic efficiency for an isolated system component
12. Analytical and numerical optimization techniques
13. Design optimization for the cogeneration system case study. Thermoeconomic optimization of complex systems.

(4) **TEACHING and LEARNING METHODS - EVALUATION**

DELIVERY ***Face-to-face, Distance learning, etc.***	Face-to-face
USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY *Use of ICT in teaching, laboratory education, communication with students*	Support of the learning process through the web platform e-class Use of powerpoint slides Upload of course material on the course's website Exercises, reports and presentation as evaluation methods

TEACHING METHODS *The manner and methods of teaching are described in detail.*
Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, placements, clinical practice, art workshop, interactive teaching, educational visits, project, essay writing, artistic creativity, etc.

The student's study hours for each learning activity are given as well as the hours of non- directed study according to the principles of the ECTS

Activity	*Semester workload*
Lectures	44
Practical exercises targeting on the understanding of the delivered theory	25
Final presentation	8
Individual project and technical report for an energy production system	43
Independent study	30
Course total	*150*

STUDENT PERFORMANCE EVALUATION ***Description of the evaluation procedure*** *Language of evaluation, methods of evaluation, summative or conclusive, multiple choice questionnaires, shortanswer questions, open- ended questions, problem solving, written work, essay/report, oral examination, public presentation, laboratory work, clinical examination of patient, art interpretation, other* *Specifically-defined evaluation criteria are given, and if and where they are accessible to students.*	I. Practical exercises(30%). At least 2 exercises per lecture that are marked independently and examine the understanding of the theory and methods. II. Individual project(50%).Application of the majority of theory and methods on a technical report submitted at the end of the semester. III. Final examination – Presentation (20%). Presentation of the individual projects, basic results and main conclusions. At the end of the presentation there will be a Q & A session.

(5) **ATTACHED BIBLIOGRAPHY**

- ***-Suggested bibliography:*** Σχεδιασμός και οικονομική μελέτη εγκαταστάσεων για μηχανικούς, 5η Βελτιωμένη Έκδοση, Peters Max,Timmerhaus Klaus D., West Ronald E. (Επιστ. επιμέλεια: Δημήτριος Μαρίνος-Κουρής, Κροκίδα Μαγδαληνή, Ζαχαρίας Μαρούλης), ΕΚΔΟΣΕΙΣ Α. ΤΖΙΟΛΑ & ΥΙΟΙ Α.Ε., 2020
- Bejan, Adrian, Thermal design and optimization / Adrian Bejan, George Tsatsaronis, Michael Moran, New York : John Wiley and Sons, c1996.
- Stoecker, Wilbert F., Design of thermal systems / W. F. Stoecker, New York : McGraw-Hill Book Company, c1989.
- Jaluria, Yogesh, Design and optimization of thermal systems / Yogesh Jaluria, New York : : The McGraw-Hill Companies, Inc., c1998.
- Janna William S.,Design of fluid thermal systems ,2nd ed. Boston ; Albany : PWS, c1998
- Boehm Robert F.,Developments in the design of thermal systems , Cambridge : Cambridge University Press, c1997

- Related academic journals: