COURSE OUTLINE

(1) GENERAL

SCHOOL	ENGINEERING		
ACADEMIC UNIT	DEPARTMENT OF MINERAL RESOURCES ENGINEERING		
LEVEL OF STUDIES	UNDERGRADUATE		
COURSE CODE	MRE303	SEMESTER	3
COURSE TITLE	THERMODYNAMICS		
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		3	4
Labs		1	1
Total		4	5
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, specialised general knowledge, skills development*	Required, *general background*		
PREREQUISITE COURSES:	There are no prerequisite courses		
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	Greek		
IS THE COURSE OFFERED TO ERASMUS STUDENTS	No		
COURSE WEBSITE (URL)	https://eclass.uowm.gr/courses/MRE128/		

(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*

Thermodynamics is taught with emphasis on its universality rather than its special applicability. More specifically learning outcomes include

- Apprehension of the universality and rigorousness of the thermodynamic principles that renders it suitable and necessary for the analysis of a wide range of technological problems
- Development of the student's ability to extract logical conclusions from the analysis of physicochemical phenomena according to the basic principles of Thermodynamics
- Consolidation of the simplicity of the basic laws of Thermodynamics and their consequence on a large number of technological problems
- Development of the ability to analyze technological problems taking into account the basic and derived thermodynamic properties
- Development of the ability to analyze thermochemical phenomena and processes involving ideal and non-ideal (i.e. steam) gases
- Development of the ability to analyze practical power and refrigeration cycles
- Comprehension of phase diagrams of pure substances and the phase rule.

- Development of the ability to analyze phase diagrams, separation processes and/or chemical reactions according to thermodynamic principles
- Knowledge of basic computational tools such as EXCEL and Mathematica as applied to solve problems of Thermodynamics
- Development of the ability to search and extract specific articles from the relevant scientific literature

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
Working independently
Team work
Working in an interdisciplinary environment
Criticism and self-criticism
Production of new Research ideas
Production of free, creative and inductive thinking
Showing social, professional and ethical responsibility

(3) SYLLABUS

Thermodynamic methods, temperature, zeroth law. First law. Energy forms, internal energy, heat, work, reversible processes.
Thermodynamic systems, state functions and definition of enthalpy.
Specific heat, phase change of pure substances, Gibbs phase rule, ideality in gases, and introduction to the concept of equilibrium.
Work calculation in ideal and non-ideal gases, steam as an example of non-ideal gas, usage of steam tables, and introduction to irreversible processes.
First law in open systems, thermochemistry and latent heat.
Second law of thermodynamics, Carnot power and refrigeration cycle, other practical power and refrigeration cycles.
Thermodynamic temperature scale, definition of entropy and its calculation in several processes. Third law of Thermodynamics, Gibbs free energy and examples of calculation of free energy change in several processes.
Thermodynamics of mixing and composition change, the concept of fugacity and activity, chemical potential, introduction to the concept of chemical equilibrium

(4) TEACHING and LEARNING METHODS - EVALUATION

DELIVERY *Face-to-face, Distance learning, etc.*	Face-to-face, Distance learning, Lectures, Computational EXCEL Lab, Tutorials
USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY *Use of ICT in teaching, laboratory education, communication with students*	E-Class, electronic communication, video demonstrations, intermediate exams via e-Class tools
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	36
Computational Lab	24
Tutorials	24
Self-study	16
Course total	***100***

STUDENT PERFORMANCE EVALUATION *Description of the evaluation procedure* *Language of evaluation, methods of evaluation, summative or conclusive, multiple choice questionnaires, short-answer 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.*	Final exam (40%, minimum required grade =4/10), Multiple choice intermediate exam (20%), Homework (20%), Computational Lab (20%)

(5) SUGGESTED BIBLIOGRAPHY

- Suggested bibliography:

1. Introduction to Chemical Engineering Thermodynamics by Smith J.M., VanNess H.C., Abbott M.M, Κωδικό στον Εύδοξο: 32999045, ISBN: 9780071247085. Εκδότης: Επίκεντρο Α.Ε.

2. Εισαγωγή στη Θερμοδυναμική (Έκδοση: 7η Έκδοση/2011), by Smith J.M., Van Ness Hendrich., Abbott M., Κωδικό στον Εύδοξο: 18549050, ISBN: 978-960-418-344-9, Εκδότης: ΕΚΔΟΣΕΙΣ Α. ΤΖΙΟΛΑ & ΥΙΟΙ Α.Ε.

3. Θερμοδυναμική και Προχωρημένη Θερμοδυναμική, by Πολυζάκης Απόστολος, Κωδικό στον Εύδοξο: 94645248, ISBN: 978-618-83590-4-8, Εκδότης: Πολυζάκης Απόστολος & ΣΙΑ ΕΕ

4. Thermodynamics. An Engineering Approach.(Έκδοση: 9/2018), by Cengel Y., Boles M., Kanoglu M., Κωδικό στον Εύδοξο: 77112397, ISBN: 9781260092684, Εκδότης: Επίκεντρο Α.Ε.

5. Θερμοδυναμική για Μηχανικούς, 9η Έκδοση, by Cengel Yunus A., Boles Michael A., Τσιακάρας Π. - Κατσαβούνης Σ. (επιμέλεια), Κωδικό στον Εύδοξο: 77110348, ISBN: 978-960-418-820-8, Εκδότης: ΕΚΔΟΣΕΙΣ Α. ΤΖΙΟΛΑ & ΥΙΟΙ Α.Ε.

6. Elementary General Thermodynamics , by Sussman M.V, ISBN: 0-201-07358-7 , Εκδότης: Addison- Wesley Publishing Company, Inc., Philippines 1972

7. Thermodynamics of Materials, Vol.I, , by Ragone D.V., ISBN: 0-471-30885-4 , Εκδότης: John Wiley & Sons, Inc., 1995

- Related academic journals::

Journal of Chemical Education (https://pubs.acs.org/journal/jceda8)

• A. Ginebreda, "Entropy and Waste Recovery: Between Thermodynamics and Economy", J. Chem. Educ., 1996, 73 (8), p 708

• Michael H. Huesemann, "Recognizing the Limits of Environmental Science and Technology", Environ. Sci. Technol., 2003, 37 (13), pp 259A–261A

• JAMES J. MORGAN, "Applications and Limitations of Chemical Thermodynamics in Natural Water Systems", Equilibrium Concepts in Natural Water Systems", Chapter 1, 1967, pp 1-29, Advances in Chemistry, Volume 67

• Michael Frenkel, "Global Information Systems in Science: Application to the Field of Thermodynamics", J. Chem. Eng. Data, 2009, 54 (9), pp 2411–2428

• Jo Dewulf, Herman Van Langenhove, Bart Muys, Stijn Bruers, Bhavik R. Bakshi, Geoffrey F. Grubb, D. M. Paulus and Enrico Sciubba, "Exergy: Its Potential and Limitations in Environmental Science and Technology" Environ. Sci. Technol., 2008, 42 (7), pp 2221–2232

• Blinder, S.M. "Mathematical Methods in elementary thermodynamics", J. Chem. Educ. (1966) 43: 85-92.

• Rosenberg R. M., "From Joule to Caratheodory and Born: A Conceptual Evolution of the First Law of Thermodynamics" J. Chem. Educ., 2010, 87 (7):691–693

• G. J. Young ond R. B. Rozelle, "Fuel Cells" J. Chem. Educ., 1959, 36 (2):68-73

• P. W. Hladky, "From Bunsen Burners to Fuel Cells" J. Chem. Educ., 2009, 86 (5):582

• A. Ben-Naim, "Mixing and assimilation in systems of interaction particles" Am. J. Phys., 1987, 55(12) 1105

• A. Ben-Naim "Entropy: Order or Information", J. Chem. Educ. 2011, 88, 594–596 (dx.doi.org/10.1021/ed100922x)