COURSE OUTLINE

(1) GENERAL

SCHOOL	Engineering		
ACADEMIC UNIT	Mechanical Engineering		
LEVEL OF STUDIES	Undergraduate		
COURSE CODE	EN0112	**SEMESTER**	3rd (fall)
COURSE TITLE	Thermodynamics II (m)		

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, Exercises	5	6
Add rows if necessary. The 1rganization of teaching and the teaching methods used are described in detail at (d).		

COURSE TYPE *general background, special background, specialized general knowledge, skills development*	General background Specialized general knowledge Skills development
PREREQUISITE COURSES:	
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	Greek, tutoring (if needed)
IS THE COURSE OFFERED TO ERASMUS STUDENTS	NO
COURSE WEBSITE (URL)	https://www.mie.uth.gr/?page_id=17782&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*

Upon successful completion of the course the student will be able to:

- Establish mass and energy balances in open systems
- Properly select control volumes in closed and open systems
- Design circular processes for thermal and refrigerant machines in the T-s diagram and identify the loss of exergy in the individual processes (compression, expansion, heat exchangers)
- Establish mass and energy balances in open combustion spaces
- Calculate the air ratio and dew point based on the exhaust composition
- Apply chemical equilibrium equations to simple reactors
- Do simple psychometric calculations

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…*
	…….

- Understand the basic concepts of thermal physics
- Search, analyze and synthesize data and information, using the necessary tools technologies
- Study calculations
- Independent work

(3) SYLLABUS

1. **Relationships of Thermodynamic Properties:** p-v-T calculations using static equations with two or more gas constants. Understanding and applying the concept of total differential calculations of thermodynamic properties. Calculate Δu, Δh and Δs using the Clapeyron equation for phase change.
2. **Ideal gas mixtures - application to psychometrics:** Description of ideal mix composition of gases through mass fractions / molecular fractions. Using the Dalton model for pressure correlation, volume and temperature and calculate U, H, and S change for ideal gas mixtures. Application mass, energy and entropy balances in ideal gas mixtures and mixing processes. Understanding psychometric terms: absolute / relative humidity, liquid air enthalpy and dew point temperature. Using the psychometric chart.
3. **Exergy analysis:** Understanding the basic concepts of exergy analysis: zero exergy reference environment, exergy transfer and destruction. Calculation of exergy as a constitutive property as well as the exergy change between two thermodynamic states, using appropriate data. Application of energy balances in closed systems as well as in control volumes in steady-state flow processes. Definition and calculations of exergy efficiency.
4. **Chemical reactions and Combustion:** Perfect combustion definition of: stoichiometrically required air, air ratio, standard enthalpy of formation, calorific value of fuel and adiabatic flame temperature. Calculations of the above quantities in the combustion of solids, liquids and exhaust gases. Calculation of air ratio based on the composition of the exhaust gases. Calculation of degree of burning efficiency. Application of mass, energy and entropy balances to closed systems and control volumes where chemical reactions take place.
5. **Chemical equilibrium and Phase equilibrium:** Explanation of basic concepts of chemical and phase equilibrium, equilibrium criteria, equilibrium constant and Gibbs phase rule. Apply the equilibrium constant equation to relate the partial pressures of reactants/products with temperature, for single or multiple chemical reactions. Application of chemical balance concepts combined with energy balances. Equilibrium flame temperature determination. Apply the Gibbs phase rule.
6. **Gas power generation cycles:** Analysis of thermodynamic cycles of internal combustion engine, based on Otto and Diesel cycles. Plotting p - V and T – s diagrams, identifying properties. Application of energy, entropy and exergy balances. Determination of power output, thermal efficiency and average pressure. Analysis of thermodynamic cycles of gas turbines based on the Brayton cycle. Implementation of energy, entropy and exergy balance. Determination of power output, thermal efficiency and back work ratio and effect of compressor pressure ratio on efficiency. Analysis of subsonic and supersonic flows through nozzles and diffusers, effect of cross-section on properties, effect of backflow on mass flow. Strangulation and shock wave appearance.
7. **Refrigeration Thermodynamics - Heat Pumps:** Understanding basic refrigerant cycles with cold vapor compression. Analysis of thermodynamic models of refrigerant cycles, illustrated in logp - h and T - s diagrams. Implementation of energy, entropy and exergy balances for the basic processes of the cycle. Definition and determination of Coefficient of Performance (COP) and cooling efficiency circles. Understand the effect of key refrigerant design and control parameters of the refrigerant cycle performance.

(4) TEACHING and LEARNING METHODS - EVALUATION

DELIVERY ***Face-to-face, Distance learning, etc.***	Face-to-face, technical examples, lab training
USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY *Use of ICT in teaching, laboratory education, communication with students*	Use of software for thermodynamics tables
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: 55 Laboratory practice: 15 Exercises: 45 Use of software: 5 Tutorials: 30 **Course total: 150**
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.*	Language of evaluation: Greek Evaluation method: conclusive Problem solving, Written work, report/essay

(5) ATTACHED BIBLIOGRAPHY

-Suggested bibliography:

- MICHAEL J. MORAN, HOWARD N. SHAPIRO, DAISIE D. BOETTNER, MARGARET B. BAILEY: Fundamentals of Engineering Thermodynamics Wiely 2014
- Hans Dieter Baehr ThermodynamikGrundlagen und technische Anwendungen 12 Auflage Springer 2005
- Borgnakke C., Sonntag R.E.-Fundamentals of Thermodynamics-8 ed. Wiley 2013.
- Mark Waldo Zemansky, Richard Dittman: Heat and thermodynamics an intermediate textbook-7 ed. McGraw-Hill (1997)

- Related academic journals:

- Brennstoff-Waerme-Kraft (VDI)