COURSE OUTLINE

(1) GENERAL

SCHOOL	School of Science		
ACADEMIC UNIT	Physics		
LEVEL OF STUDIES	Undergraduate		
COURSE CODE	**41**	**SEMESTER**	**4**
COURSE TITLE	Thermodynamics and Heat Laboratory		

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 (5 hours) + Laboratory (1 hour)	6	7
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*	General background and skills development.
PREREQUISITE COURSES:	
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	Greek
IS THE COURSE OFFERED TO ERASMUS STUDENTS	Yes
COURSE WEBSITE (URL)	http://ecourse.uoi.gr/course/view.php?id=786

(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*

The course provides the student with knowledge to understand the principles and phenomena of Heat and Thermodynamics as well as the mathematical techniques necessary to solve related problems. Apart from the theoretical part, there is also the laboratory part of the course, where in order to better consolidate the theory, the students perform experiments, collect and analyze experimental data and write homeworks. In particular, after the successful completion of the course, the students will be able:

• to interpret and draw qualitative and quantitative conclusions about temperature measurement, to distinguish the concepts of temperature, heat, internal (thermal) energy and entropy, to understand the concept of thermal equilibrium, the heat transfer, the generalized principle of conservation of energy, the energy conversions, the principle of operation of thermal and cooling engines and generally the laws of thermodynamics.,

• To apply mathematical procedures in order to calculate analytically the production of work and heat, the change in internal (thermal) energy of a system, the efficiency of the thermal and cooling machines and entropy changes.

• To formulate problems in Thermodynamics and to use appropriate mathematical methods for solving them.

• To use the concepts of thermodynamic potentials, such as the enthalpy, the Helmholtz energy and the Gibbs free energy, for the energy changes of systems.
• To apply the acquired theoretical knowledge to successfully conduct experiments, in order to confirm the principles and laws of Thermodynamics.

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, analyze and synthesize data and information, using the necessary technologies.
• Autonomous and team work.
• Promotion of free, creative and inductive thinking.

(3) SYLLABUS

Theoretical part: The basic thermodynamic concepts. The thermodynamic equilibrium and the zeroth law of thermodynamics. Microscopic and macroscopic description of thermodynamic systems. Definition and measurement of temperature. Thermometers. Heat and its transport. Calorimetry. The gas laws and the ideal gas equation. The ideal gas kinetic model. Real gases and Van der Waals equation. State quantities, functions and perfect differentials. Other simple thermodynamic systems. Work, internal (thermal) energy and the first law of thermodynamics. P-V and P-T diagrams. Work on hydrostatic and non-hydrostatic systems. Semi-static and reversible processes. Specific molar heat capacities c_p and c_v. Adiabatic procedures. Work-heat conversions, heat and refrigerating engines, and their efficiencies. The second law of thermodynamics and the Carnot cycle. The Clausius theorem and inequality. Entropy and measurement of its changes. The entropic principle. The absolute zero and the third law of thermodynamics. The thermodynamic potentials of enthalpy, Helmholtz energy and Gibbs energy. The Maxwell's relations. TdS and internal energy thermodynamic relations. Phase changes and open systems. The chemical potential.

Laboratory part: Conducting laboratory exercises in groups of 2 students each. The exercises concern the following experiments: 1. Thermocouple calibration. 2. Study of thermal expansion of solids and liquids. 3. Specific heat of liquids and solids, the Dulong-Petit law for metals. 4. Gas laws and measurement of absolute zero. 5. Measurement of the adiabatic coefficient γ=cp/cv of the air. 6. Thermal engine efficiency measurement.

(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*	Use of the e-courses learning system, with uploaded notes and exercises for practice and communication with students
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.*	

Activity	***Semester workload***
Lectures	42
Tutorials	13
Laboratory exercises	10
Study of bibliography	80
Non-directed study	25
Exams	5

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		
	Course total	**175**
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.*	Homework with problem solving and evaluation, on an almost weekly basis (15%). Midterm exams (20%). Laboratory exercises and delivery of written reports (30%). The corrected reports are returned to students. Written exams at the end of the semester which concern the understanding of the theory and solving problems (35%). The percentage in parentheses is the contribution of each evaluation process to the final grade of the course.	

(5) ATTACHED BIBLIOGRAPHY

- Suggested bibliography:
- Heat and Thermodynamics, M. Zemansky, R. Dittman, Copyright © 1997, The Mc Graw-Hill Companies, Inc, ISBN 0-07-114816-7.
- Θερμότητα και Θερμοδυναμική, M. Zemansky, Εκδόσεις Α. Γ. Πνευματικός, Αθήνα (2015), ISBN 978-960-72585-0-2.
- Εισαγωγή στη Θερμότητα και τη Θερμοδυναμική, Ι. Γραμματικάκης, Εκδόσεις Leader Books, Αθήνα, (2012), ISBN 978-960-99459-4-3.
- Αρχές Θερμοδυναμικής για Μηχανικούς, John R. Reisel, Εκδόσεις Κλειδάριθμος, Αθήνα (2021), ISBN 978-960-645-190-4
- Θερμοδυναμική και Προχωρημένη Θερμοδυναμική, Α. Πολυζάκης, Εκδόσεις PHC, Πτολεμαΐδα, (2021), ISBN 978-618-83590-4-8