UNICUSANO ROME

Code: ING-IND/08 **Credits: 9**
Matter: Applied Thermodynamics
Main language of instruction: Italian
Other language of instruction: English

Teaching Staff

Head instructor

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Introduction

1. *Objective of the course :*

The aim of Technical Physics course is to provide the student with a good knowledge of basic thermodynamics and its application in simple energy systems. The course proposes the basic concepts of thermodynamics, psychrometry and heat transmission and declines them in the study of thermodynamic devices of common use, with particular reference to energy and performance analyses, at macroscopic level and in steady state, for preliminary sizing of thermal plants, air treatment units and heat exchangers. This basic knowledge also involves the study of fluids used in the most common energy systems, also known as working fluids, in order to evaluate their properties in different thermodynamic states. The e-tivities associated with the course develop the skills necessary to formulate the problems of thermodynamics through the use of computational systems.

Objectives

2. *Course Structure:*

The course has the following objectives:

1. Review of the fundamental principles of thermodynamics
2. To illustrate the thermodynamic behavior of pure substances and mixtures of air and water vapor
3. Illustrate the thermodynamic analysis of real energy conversion processes, through analytical relationships
4. Illustrate the thermodynamic analysis of air conditioning processes, through analytical and graphical methods

5. Illustrate the mechanisms of heat transmission and related fundamental laws
6. Provide a simplified representation of real heat exchange processes

Competencies:

At the end of the course, the student should be able to:

- understand the nature and role of the thermodynamic properties of matter;
- access thermodynamic property data from different sources;
- chart thermodynamic processes on thermodynamic diagrams;
- distinguish the system from its surroundings, and identify work and/or heat interactions between the system and surroundings;
- recognize the different forms of energy and restrictions imposed by the first law of thermodynamics on conversion from one form to another;
- apply the first law to a control mass or control volume;
- understand implications of the second law of thermodynamics and limitations placed by the second law on the performance of thermodynamic systems;
- understand the difference between ideal and real behavior of a systems;
- describe and make a preliminary analysis of the behavior of steam power plants, gas power plants, internal combustion engines, cooling systems and heat pumps;
- understand the differences between the existing heat transfer mechanisms and being able to apply these concepts to the study of steady, mono-dimensional heat transfer problems;
- apply thermodynamics and heat transfer fundamentals to the particular application of heat exchangers

Syllabus

3. *Programme of the course:*

Subject 1 - Introductory concepts: Unit of measurement. Basic definitions. Thermodynamic quantities. Temperature scales**.**

Subject 2 - First principle of thermodynamics: Introduction to the concepts of work and heat. The principle of conservation of energy and mass. Derivation of the First Principle of Thermodynamics and its characterization for closed and open systems.

E-tivity 1 - Subjects 1 and 2

Subject 3 - Technical fluids: Properties of substances: thermal capacity and specific heats. Perfect gas behavior and differences with real gases. Derivation of the state law of perfect gases. Wet steam, state changes and state diagrams. Understanding and use of wet vapor property tables in its thermodynamic states.

Subject 4 - Second law of thermodynamics: The Second Principle of Thermodynamics. The concepts of reversibility and irreversibility and the Entropy function. Carnot cycle and thermodynamic temperature.

E-tivity 2 - Subjects 3 and 4 (total commitment of about 2 h)

Subject 5 - Direct cycles: Thermodynamic cycles for the production of work with ideal gases. Otto, Diesel, Sabathé and Joule-Brayton cycles and their modifications. Steam-based thermodynamic cycles for the power generation. Rankine, Hirn cycles and their modifications.

E-tivity 3 - Subject 5 (total commitment of about 2 h)

Subject 6 - Reverse cycles: Reverse cycles for cooling and/or heat generation: refrigeration machines and heat pumps. Main properties of refrigerant fluids.

E-tivity 4 - Subject 6

Subject 7 - Psychrometry: Characterization of wet air mixtures. Main transformations of these mixtures and use of psychrometric diagrams. Application for the sizing of air conditioning systems.

E-tivity 5 - Subject 7 (total commitment of about 2 h)

Subject 8 – Heat Transfer & Conduction: Principles of heat transfer. Conduction heat transfer mechanism.

Subject 9 - Convection: Mechanism of heat transfer by convection. Combined mechanisms of heat transfer by conduction and convection.

Subject 10 - Radiation: Radiation heat transfer mechanism. Combined heat transfer mechanisms.

Subject 11 - Heat exchangers: Application of heat transfer principles and thermodynamic principles to the case of heat exchangers.

E-tivity 6 - Subjects 8-11

Evaluation system and criteria

The examination test consists in a written test lasting 90 minutes.

The test can be carried out in a single solution or divided into two partial exams, to be taken in two different dates.

In the case of ENTIRE EXAM, the test consists of three exercises, on the following topics:

1. first and second principles of thermodynamics and / or thermodynamic transformations (Subjects 1-6);
2. psychrometry (Subject 7);
3. heat transfer and its applications (Subjects 8-11).

The maximum score of each exercise is 9 and the test entitles you to a maximum of 27 points.

In case of TWO PARTIAL EXAMS, each test consists of two exercises, divided as follows:

- TEST 1: two exercises on the first and second principle of thermodynamics and/or thermodynamic processes (Subjects 1-6);

- TEST 2: an exercise on psychrometry (Subject 7) and an exercise on heat transfer and its applications (Subjects 8-11).

The maximum score for each exercise is 13.5 points. It is possible to take part to the second partial examination if and only if the score obtained in the first test is greater than or equal to 13. The final score will then be given by the average of the votes of the two partial tests and it is possible to score a maximum of 27 points.

Up to 6 points are associated with the 6 e-tivities (1 point for each passed e-tivity) and will be summed to the total score obtained with the written exam. The e-tivities will be accounted for only with scores greater than or equal to 13. A total score from 31 to 33 will result in a final grade of 30/30 Lode.

E-tivities are optional, although strongly recommended. If the student decides not to carry out the e-tivities, the final grade will be appropriately converted, considering a maximum score of 30 instead of 27. This conversion applies only to the case of **non-performed e-tivities** and not to the case of failed e-tivities.

Bibliography and resources

4. *Materials to consult:*

Lecture Notes: Lecture notes available online completely cover the course syllabus and are integrated by slides and video-lessons. This material is necessary and sufficient for the study of the subject.

5. *Recommended bibliography:*

- *Y. Çengel, Termodinamica e Trasmissione del Calore, McGraw-Hill*
- *F. Kreith, Principi di trasmissione del calore, Liguori editore*
- *M. J. Moran, H. N. Shapiro, B. R. Munson, D. P. Dewitt, Introduction to Thermal Systems Engineering: Thermodynamics, Fluid Mechanics, and Heat Transfer, John Wiley & Sons, Inc. , ISBN: 978-0-471-20490-9*
- *M. A. Cucumo, V. Marinelli, Termodinamica applicata, Pitagora editrice Bologna*
- *A. Cavallini, L. Mattarolo, Termodinamica Applicata, CLEUP editore*
- *C. Bonacina, A. Cavallini, L. Mattarolo, Trasmissione del Calore, CLEUP editore*