| Code | VI.5 |
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| Course Title (English) | Engineering Physics-Thermodynamics |
| Course Title (Polish) | Fizyka techniczna – Termodynamika |
| Credits | 5 ECTS |

*Language of instruction* **English**

*Compulsory for Profile:* Computer Modelling and Simulation (CMS), Intelligent Energy (IE), Biotechnology for Environmental Protection (BI), Business and Technology (BT)

*Type of studies* BSc studies

*Unit running the programme* Institute of Thermal Machinery

***Course coordinator** and academic teachers* **Andrzej Bogusławski, Assoc. Prof.,** Andrzej Bogusławski, Assoc**.** Prof., Witold Elsner, Assoc**.** Prof, Piotr Pełka, Ph.D.

*Form of classes and number of hours*

| Semester | Lec. | Tut. | Lab. | Proj. | Sem. | Credit points |
| --- | --- | --- | --- | --- | --- | --- |
| VI | 30 | 15 | 15 | | | 5 |

*Learning outcomes* ** The outcome of the course is the ability of the student to understand the basic concepts of energy conversion, first and second law of thermodynamics, thermodynamic cycles, process efficiency, properties of pure substances and mixtures, basic gas power cycles, V

vapor and combined power cycles, chemical and phase change thermodynamic properties

*Prerequisites (courses)* none

*Prerequisites (mathematical tools)* Basic knowledge of differential and integration calculus, basic knowledge on ordinary and partial differential equations, concept of energy, work and heat,

*Course description* LECTURE

**Baisc concepts:** nature of thermodynamics, system and control volumes, continuum concept, state and equilibrium, processes and cycles, temperature and zeroth law of thermodynamics
**Energy, energy transfer, general energy analysis:** internal energy, heat transfer, work, first law of thermodynamics, energy conversion efficiency

**Properties of pure substances:** concept of a pure substance, phase-change processes, ideal gas, ideal gas equation of state, application of other state equations

**Energy analysis of closed systems:** Develop the general energy balance applied to closed systems, Define the specific heat at constant volume and the specific heat at constant pressure, Relate the specific heats to the calculation of the changes in internal energy and enthalpy of ideal gases, Describe incompressible substances and determine the changes in their internal energy and enthalpy, Solve energy balance problems for closed (fixed mass) systems that involve heat and work interactions for general substances

**Mass and energy analysis of control volume:** Develop the conservation of mass principle. Apply the conservation of mass principle to various systems including steady- and unsteady-flow control volumes, Apply the first law of thermodynamics as the statement of the conservation of energy principle to control volumes, Identify the energy carried by a fluid stream crossing a control surface as the sum of internal energy, flow work, kinetic energy, and potential energy of the fluid and to relate the combination of the internal energy and the flow work to the property enthalpy, Solve energy balance problems for common steady-flow devices such as nozzles, compressors, turbines, throttling valves, mixers, heaters, and heat exchangers, apply the energy balance to general unsteady-flow processes with particular emphasis on the uniform-flow process as the model for commonly encountered charging and discharging processes

**Second law of Thermodynamics:** Introduce the second law of thermodynamics. Identify valid processes as those that satisfy both the first and second laws of thermodynamics. Discuss thermal energy reservoirs, reversible and irreversible processes, heat engines, refrigerators, and heat pumps. Describe the Kelvin–Planck and Clausius statements of the second law of thermodynamics. Discuss the concepts of perpetual-motion machines. Apply the second law of thermodynamics to cycles and cyclic devices. Apply the second law to develop the absolute thermodynamic temperature scale. Describe the Carnot cycle. Examine the Carnot principles, idealized Carnot heat engines, refrigerators, and heat pumps. Determine the expressions for the thermal efficiencies and coefficients of performance for reversible heat engines, heat pumps, and refrigerators.

**Entrophy:** Apply the second law of thermodynamics to processes. Define a new property called *entropy* to quantify the second-law effects. Establish the *increase of entropy principle*. Calculate the entropy changes that take place during processes for pure substances, incompressible substances, and ideal gases. Examine a special class of idealized processes, called *isentropic processes*, and develop the property relations for these processes. Derive the reversible steady-flow work relations. Develop the isentropic efficiencies for various steady-flow devices. Introduce and apply the entropy balance to various systems.

**Exergy:** Examine the performance of engineering devices in light of the second law of thermodynamics. Define *exergy*, which is the maximum useful work that could be obtained from the system at a given state in a specified environment. Define *reversible work*, which is the maximum useful work that can be obtained as a system undergoes a process between two specified states. Define the exergy destruction, which is the wasted work potential during a process as a result of irreversibilities. Define the *second-law efficiency*. Develop the exergy balance relation. Apply exergy balance to closed systems and control volumes.

**Gas Power cycles:** Evaluate the performance of gas power cycles for which the working fluid remains a gas throughout the entire cycle. Develop simplifying assumptions applicable to gas power cycles. Review the operation of reciprocating engines. Analyze both closed and open gas power cycles. Solve problems based on the

Otto, Diesel, Stirling, and Ericsson cycles.

**Vapor and combined power cycles:** Analyze vapor power cycles in which the working fluid is alternately vaporized and condensed. Analyze power generation coupled with process heating called *cogeneration*. Investigate ways to modify the basic Rankine vapor power cycle to increase the cycle thermal efficiency. Analyze the reheat and regenerative vapor power cycles. Analyze power cycles that consist of two separate cycles known as combined cycles and binary cycles.

**Gas mixtures, gas and vapor mixtures:** Develop rules for determining nonreacting gas mixture properties from knowledge of mixture composition and the properties of the individual components. Define the quantities used to describe the composition of a mixture, such as mass fraction, mole fraction, and volume fraction, Differentiate between *dry air* and *atmospheric air*. Define and calculate the specific and relative humidity of atmospheric air. Calculate the dew-point temperature of atmospheric air. Relate the adiabatic saturation temperature and wet-bulb temperatures of atmospheric air.

**Chemical and phase equilibrium:** Develop the equilibrium criterion for reacting systems based on the second law of thermodynamics. Develop a general criterion for chemical equilibrium applicable to any reacting system based on minimizing the Gibbs function for the system, Establish the phase equilibrium for nonreacting systems in terms of the specific Gibbs function of the phases of a pure substance. Apply the Gibbs phase rule to determine the number of independent variables associated with a multicomponent, multiphase system

TUTORIALS:

Students learn fundamental concepts and how to use them for solving real-world engineering problems. Major topics:
Properties and units, Energy and energy transfer, Work, Ideal gas, Clapeyron equation, Heat engines and refrigerators, Device Second Law Efficiency, Ideal gas Carnot cycles, Vapor and Rankine Cycle

LABORATORY:
Error of measurement, data handling, international system of units, Measurement of temperature, Classification of apparatus to measurement of temperature, Measurement of pressure, Humidity of air (absolute and relative), Measurement of mass and volume, Convective and overall heat transfer coefficient, Measurement of specific heat, Application of pyrometer in measurement of temperature.

PROJECT
Not applicable
SEMINAR
Not applicable

*Form of assessment* Exam

*Basic reference materials* 1.


1. Shavit A., Gutfinger C., Thermodynamics: From Concepts to Applications, CRC Press, 2008

2. Engel T., Reid P., Thermodynamics, Statistical Thermodynamics, & Kinetics, Benjamin Cummings, 2006

3. Janna W.S., Engineering Heat Transfer, Third Edition, CRC Press, 2009

4. Cengel, Y.A., Boles M.A., Thermodynamics, an engineering approach, 5th ed., New York, McGraw-Hill, 2006

5. Moran M.J., Shapiro H.D.: Fundamentals of engineering thermodynamics, John Wiley & Sons, 2000R.E. Sonntag, C. Borgnakke, G.J. Van Wylen, Fundamentals of Thermodynamics, 6th Edition, John Wiley & Sons, 2003


*Other reference materials*

For Polish-speaking students:


6. A. Tarnogrodzki, Dynamika Gazów, WKŁ, 2003

7. S. Ochęduszko, J. Szargut i inni, Zbiór zadań z termodynamiki technicznej, PWN, Warszawa, 1975

8. W. Gajewski, Laboratorium z termodynamiki i wymiany ciepła, Wydawnictwa Politechniki Częstochowskiej, Częstochowa 2005


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| Average student workload (teaching hours + individ. ) | 4 teaching hours +3 hours of individual work per week |
| Remarks: | |
| *Updated on: 30.09. 2014* | |