Course description

1 General information

Course name	Heat and mass transfer
Course code	06.1
Level of study (B.Sc, M.Sc., Ph.D.)	B.Sc.
ECTS	5
Course manager	Prof. dr hab. inż. Piotr Duda, Institute of Thermal and Process Engineering, M-05
Course length	One (1) semester
Coordinator for international programs	erasmus@mech.pk.edu.pl

2 Prerequisites

- completed courses in mathematics and physics

3 Program

Type	Lectures	Classes	Labs	Computer labs	Project	Seminar
Hours	30	30	0	0	0	0

4 Contents

Lectures		
No.		Hours
1	Basics of heat transfer.	1
2	Heat conduction equation: Steady versus transient heat transfer; One-dimensional heat conduction equation; General heat conduction equation; Boundary and initial conditions; Heat generation in a solid; Thermal contact resistance; Heat transfer from finned surfaces.	2
3	Transient heat conduction: Lumped system analysis; Criteria for lumped system analysis; Transient heat conduction in large plane walls, long cylinders and spheres; Transient heat conduction in semi-infinite solids; Transient heat conduction in multidimensional systems.	2
4	Convection: Physical mechanism on convection; Velocity and thermal boundary layer; External forced convection; Internal forced convection; Natural convection; Boiling and condensation;	2
5	Radiation heat transfer: Blackbody radiation; Radiation intensity; Intensity of emitted radiation; Incident radiation; Radiosity; Spectral quantities; Radiative properties; View factor relations; Black surfaces; Diffuse and gray surfaces; Radiation exchange with emitting and absorbing gases.	2
6	Heat exchangers: Types of heat exchangers; The overall heat transfer coefficient; Fouling factor; Analysis of heat exchangers; The log mean temperature difference method; Counter-flow heat exchangers; Multipass and cross-flow heat exchangers; Use of a correction factor; The effectiveness–NTU method.	1
7	Mass Transfer: Mass diffusion; Fick's law; Mass convection; Simultaneous heat and mass transfer; Interphase mass transfer; Absorption and stripping; Distillation; Liquid-liquid extraction; Humidification operations; Membranes.	3
8	Mass Exchangers: System Balances; Single-Stream Mass Exchangers; Two-Stream Mass Exchangers; Simultaneous Heat and Mass Exchangers	2

Classes		
No.		Hours
1	One-dimensional heat conduction: Heat loss through a steam pipe; Heat loss through double-pane windows; Heat transfer to a spherical container. Equivalent heat transfer coefficient in	4

	exchangers with extended surfaces.	
2	Transient heat conduction: Temperature measurement by thermocouples; Boiling eggs; Heating of large brass plates in an oven.	4
3	Convection: Temperature rise of oil in a journal bearing; Flow of hot oil over a flat plate; Cooling of plastic sheets by forced air; Cooling of a steel ball by forced air; Flow of oil in a pipeline through a lake; Heating of water by resistance heaters in a tube; Nucleate boiling of water in a pan.	6
4	Thermal radiation: Radiation emission from a black ball; Emission of radiation from a lightbulb; Selective absorber and reflective surfaces; Installing reflective films on windows; Radiation heat transfer in a black furnace; Radiation heat transfer between parallel plates.	4
5	Heat exchangers: Overall heat transfer coefficient of a heat exchanger; Effect of fouling on the overall heat transfer coefficient; The condensation of steam in a condenser.	2
6	Mass Transfer: Concentration of the feed to a gas absorber; Steady-state one dimensional binary flux calculation; Loss of hydrogen from the storage tank; Catalytic conversion of carbon monoxide; Sublimation of a naphthalene model;	5
7	Mass Exchangers: Removal of carbon monoxide from automobile exhaust; Scrubbing of sulfur dioxide from steam generator; Controlling resistances of gas absorption; A natural draft cooling tower for a power plant.	5

5 Learning Outcomes (skills and knowledge):

- The student is able to define the mechanisms of heat transfer.
- The student can write down the expressions for the physical laws that govern each mode of heat transfer, and identify the variables involved in each relation.
- The student is able to define the combined heat transfer coefficient.
- The student can give the difference between the fin effectiveness and the fin efficiency.
- The student is able to define the types of convective heat transfer.
- The student is able to define the total and spectral blackbody emissive powers.
- The student is able to define spectral emissivity of a medium of thickness L in terms of the spectral absorption coefficient.
- The student is able to explain the effectiveness–NTU method and the LMTD method for heat exchanger analysis.
- The student is able to classify types of mass transfer.
- The student is able to calculate concentrations, mass fluxes, dimensions of a reactor suitable for mass transfer.

6 Assessment policy (examination):

- Passed theoretical (lecture) exam
- Passed practical (classes) exam
- The final grade is evaluated as the weighted average of grades from: practical exam (0.5) and theoretical exam (0.5)

7 Literature

1. A. Mills, Heat and Mass Transfer, CRC Press, London 2009.
2. F. P. Incropera et. al., Fundamentals of Heat and Mass Transfer, John Wiley & Sons, 2007.
3. J. Taler, P. Duda, Solving Direct and Inverse Heat Conduction Problems, Springer, Berlin 2006.
4. J. Benitez, Mass Transfer Operations, John Wiley & Sons, 2009.