# COURSE DESCRIPTION CARD - SYLLABUS

Course name

Heat and Mass Transfer

## Course

Field of study

Environmental Engineering Second-cycle Studies

Area of study (specialization)

Heating, Air Conditioning and Air Protection

Level of study

Second-cycle studies

Form of study

part-time

Year/Semester

1/1

Profile of study

general academic

Course offered in

polish

Requirements

compulsory

## Number of hours

Lecture

20

Tutorials

16

Laboratory classes

16

Projects/seminars

Other (e.g. online)

## Number of credit points

6

## Lecturers

Responsible for the course/lecturer:

prof.dr hab.inż. Janusz Wojtkowiak

email: janusz.wojtkowiak@put.poznan.pl

tel.61 6652442

Faculty of Environmental Engineering and Energy

ul. Berdychowo 4, 61-131 Poznań

Responsible for the course/lecturer:

## Prerequisites

1.Knowledge: Mathermatics: differential and integral equations and their solutions. Physics, Thermodynamics,Fluid mechanics - basics.

2.Skills:

Application of differential and integral equations for description of physical phenomena, solution of differential equations. Thermodynamics: analysis of thermodynamic problems and realization of measurements and investigations.

3.Social competencies:

Awareness of the need of permanent updating and supplementing knowledge and engineering skills.

## Course objective

Extension of knowledge and skills of heat and mass transfer calculations and measurement of heat fluxes appearing in build and natural environmental engineering

## Course-related learning outcomes

Knowledge

1. Student has a wider knowledge and calculation skill concerning heat and mass transfer and heat measurements needed for solving advanced thermal problems in environmental engineering appearing in build and natural environment. (achieved during lectures and tutorials) - [KIS2_W01; KIS2_W03; KIS2_W04]

2. Student knows basic methods needed for theoretical and design solution of thermal problems appearing in environmental engineering. (achieved during lectures and tutorials) - [KIS2_W01; KIS2_W03; KIS2_W04]

3. Student has a knowledge concerning detailed ruls of methods and calculations of heat and mass transfer and heat exchanders appearing in environmental engineering. (achieved during lectures, tutorials and laboratory exercises) - [KIS2_W01; KIS2_W03; KIS2_W04]

4. Student has an advanced knowledge concerning development tendencies and new achievements in heat equipment and processes in environmental engineering. (achieved during lectures, tutorials and laboratory exercises) - [KIS2_W01; KIS2_W03; KIS2_W04

Skills

1. Student can find adequate relationships describing analysed heat processes. (achieved during lectures and tutorials) - [KIS2_U03; KIS2_U04]

2. Student knows how determine thermodynamic properties needed for heat and mass transfer calculations (achieved during tutorials and laboratory exercises) - [KIS2_U03; KIS2_U04]

3. Student can recognize and solve advanced design and operation heat and mass transfer problems occurred in heat equipment (achieved during tutorials and laboratory exercises) - [KIS2_U03; KIS2_U04]

4. Student can critically estimate a design solution and recognize a danger hazard in erected and operated heat equipment and an critically analyse obtained results of calculations and measurements and develop conclusions(achieved during lectures, tutorials and laboratory exercises) - [KIS2_U03; KIS2_U04]

5. Student can plan and realize operating tests and prototype investigations of equipment appearing in environmental engineering and can determine an accuracy and analyse obtained results of calculation and measurements (achieved during tutorials and laboratory exercises) - [KIS2_U03; KIS2_U04]

Social competences

1. Student understand and appreciate a team cooperation in solving theoretical and practical problems (achieved during lectures, tutorials and laboratory exercises) - [KIS2_K03; KIS2_K04]

2. Student is aware of the range and limits of the used calculation methods and relationships as well as importance of possessed a theoretical and practical knowledge (achieved during lectures, tutorials and laboratory exercises) - [KIS2_K03; KIS2_K04]

3. Student understands a need of examination and verification of results of used calculation and experimental methods.(achieved during lectures, tutorials and laboratory exercises) - [KIS2_K03; KIS2_K04]

4. Student is aware of need of innovation (achieved during lectures, tutorials and laboratory exercises) - [KIS2_K03; KIS2_K04]

## Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Lectures:

The final exam consists of two parts:

Part 1: Test of understanding of fundamentals of heat and mass transfer (3 to 5 questions).

Part 2: Test of competence conc. solving of heat and mass transfer engineering problems (2 of 3 problems).

In some cases an oral examination is used. Also an activity of students during lectures and tutorials is taken into account.

To pass each of the two parts of the exam (as well as to pass the tutorials) there is necessary to obtain at least 50% of the maximum points (max=20 points). The exam is passed if both part 1 and part 2 are passed. Corrected (Improved) is only this part which was failed.

Grading system:

0-9 points = 2,0 (failed)

10-12 points = 3,0 (sufficient)

13-14 points = 3,5 (sufficient plus)

15-16 points = 4,0 (good)

17-18 points = 4,5 (good plus)

19-20 points = 5,0 (very good)

Tutorials:

60-minute written test at the end of semester (solution 2 or 3 problems). Continuous assessment of student activity (reward of activity)

Laboratory training (exercise):

Short 15 minute entrance test before each laboratory training and final assessment of the written raport and eventual oral presentation of the results.

### Programme content

Introduction to heat transfer. Heat flux. Mechanisms of heat transfer by conduction, convection and radiation. Fourier law, heat conduction equation, boundary and initial conditions. Conductivity and overall heat transfer through plat plate, cylindrical walls and finned walls. Theory of single fine. Two-dimensional steady-state conduction. Transient heat conduction lumped capacitance method, Biot and Fourier numbers. Heating and cooling of plate and regular bodies. Introduction to the numerical methods. Introduction to convection, continuity, mmomentum and energy equation, boundary layer equations, Nusselt, Reynolds, Prandtl and Grashof numbers. Heat convection in external and internal flows. Free convection. Convection in atmospheric air. Convection in boiling and condensation. Heat transfer by radiation, solar radiation.

Heat exchangers, types of heat exchangers, theory of heat exchanger, overall heat transfer coefficient, log mean temperature difference. Methods of heat excganger calculations: logaritmic and effectiveness-NTU methods. Compact heat exchangers. Effect of foulling on heat exchanger rate and pressure losses.

Diffusion mass transfer, Fick law, diffusion coefficient. Diffusion in gases, liquids and solids. Introduction to mass convection: Sherwood and Schmidt numbers. Correlation equations for mass convection. Momentum, heat and mass transfer analogy. Application of mass and heat convection for psychrometry (wet and dry thermometers), evaporation of liquid water in atmospheric air.

### Teaching methods

Classical lecture with elements of conversation

Tutorials: solving problems method

Laboratory exercises: teaching by experimentation

### Bibliography

Basic

1. Wiśniewski St., Wiśniewski T.S., Wymiana ciepła. WNT, Warszawa 2000

2. Kostowski E., Przepływ ciepła. Wyd. Polit. Śląskiej, Gliwice, 1986

3. Madejski J., Teoria wymiany ciepła. Wyd. Ucz. Politechniki Szczecińskiej, Szczecin 1998

4. Oleśkowicz-Popiel C., Wojtkowiak J., Eksperymenty w wymianie ciepła. Wyd. II rozszerzone, Wyd. Politechniki Poznańskiej, Poznań 2007

5. Oleśkowicz-Popiel C., Wojtkowiak J., Właściwości termofizyczne powietrza i wody, PRZEZNACZONE DO OBLICZEŃ PRZEPŁYWÓW I WYMIANY CIEPŁA. Wyd. Politechniki Poznańskiej, Poznań 2010

6. Staniszewski B., Wymiana ciepła. Podstawy teoretyczne. PWN, Warszawa 1979, 1980

7. Pomiary cieplne, T. 1 i T. 2, Praca zb. (red. T.R. Fodemski), WNT, Warszawa 2001

8. Hobler T., Ruch ciepła i wymienniki. WNT, Warszawa 1979

9. Kalinowski E., Przekazywanie ciepła i wymienniki. Skrypt Politechniki.Wrocławskiej, Wrocław 1995

10. Zbiór zadań z przepływu ciepła. Pod red. E. Kostowskiego, Wyd. Polit. Śląskiej, Gliwice 2001

11. Oleśkowicz-Popiel C., Czujniki strumieni ciepła. Wyd. Politechniki Poznańskiej, Poznań 1986

12. Pogorzelski J.A., Fizyka cieplna budowli, PWN, Warszawa 1976

13. Modelowanie numeryczne pól temperatury. Pod red. J. Szarguta. WNT, Warszawa 1992

14. Taler J., Duda P., Rozwiązywanie prostych i odwrotnych zagadnień przewodzenia ciepła. WNY, Warszawa, 2003

15. Zarzycki R., Wymiana ciepła i ruch masy w inżynierii środowiska. WNT, Warszawa 2005

Additional

1. Incropera F.P., De Witt D.P., Bergman T.L., Lavine A.S., Introduction to Heat and Mass Transfer. 5th Ed., John Wiley and Sons, 2007

2. Incropera F.P., De Witt D.P., Bergman T.L., Lavine A.S., Fundamentals of Heat and Mass Transfer. 6th Ed., John Wiley and Sons, 2006

3. Bejan A., Kraus A.D., Heat Transfer Handbook, John Willey sons Sons, Inc., 2003

4. Eckert E.R.G., Drake R.M., Analysis of Heat and Mass Transfer. McGraw-Hill Book Co., 1972

5. Holman J.P., Heat Transfer, McGraw Hill, Metric Edition, 2010

6. Kakac S., Liu H., Heat exchangers: Selection, Rating, and Design. CRC Press, 1998

7. Howell J.R., Siegel R., Menguc M.P., Thermal Radiation Heat Transfer. CRC Press and Taylor and Francis Group, New York 2011

**Breakdown of average student's workload**

| | Hours | ECTS |
|---|---|---|
| Total workload | 150 | 6,0 |
| Classes requiring direct contact with the teacher | 52 | 2,0 |
| Student's own work (literature studies, preparation for laboratory classes/tutorials, preparation for tests/exam) [1] | 98 | 4,0 |

[1] delete or add other activities as appropriate