STUDY MODULE DESCRIPTION FORM

Name of the module/subject		Code
Heat and Mass Transfer		**1010102211010130346**
Field of study: **Environmental Engineering Second-cycle**	Profile of study (general academic, practical): **(brak)**	Year /Semester: **1 / 1**
Elective path/specialty: **Heating, Air Conditioning and Air Protection**	Subject offered in: **Polish**	Course (compulsory, elective): **obligatory**
Cycle of study: **Second-cycle studies**	Form of study (full-time,part-time): **full-time**	
No. of hours: Lecture: **30** Classes: **30** Laboratory: **30** Project/seminars: **-**		No. of credits: **6**
Status of the course in the study program (Basic, major, other): **(brak)**	(university-wide, from another field): **(brak)**	
Education areas and fields of science and art: **technical sciences** / **Technical sciences**		ECTS distribution (number and %): **100 6%** / **100 6%**

Responsible for subject / lecturer:

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Prerequisites in terms of knowledge, skills and social competencies:

1	**Knowledge**	Mathermatics: differential and integral equations and their solutions. Physics at level 5KRK. Thermodynamics at level 6KRK. Fluid mechanics at level 6 KRK.
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 at level 6 KRK
3	**Social competencies**	Awareness of the need of permanent updating and supplementing knowledge and engineering skills.

Assumptions and objectives of the course:

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

Study outcomes and reference to the educational results for a field of study

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) - [K2_W03, K2_W04, K2_W07]

2. Student knows basic methods needed for theoretical and design solution of thermal problems appearing in environmental engineering. (achieved during lectures and tutorials) - [K2_W03, K2_W04, K2_W07]

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) - [K2_W03, K2_W04, K2_W07]

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) - [K2_W03, K2_W04, K2_W07]

Skills:

1. Student can find and estimate information gained from literature and internet concerning heat engineering equipment appearing in environmental engineering. (achieved during lectures, tutorials and laboratory exercises) - [K2_U01, K2_U18]

2. Student can find adequate relationships describing analysed heat processes. (achieved during lectures and tutorials) - [K2_U01, K2_U18]

3. Student knows how determine thermodynamic properties needed for heat and mass transfer calculations (achieved during tutorials and laboratory exercises) - [K2_U01, K2_U18]

4. Student can recognize and solve advanced design and operation heat and mass transfer problems occurred in heat equipment (achieved during tutorials and laboratory exercises) - [K2_U01, K2_U18]

5. Student can critically estimate a design solution and recognize a danger hazard in erected and operated heat equipment (achieved during lectures, tutorials and laboratory exercises) - [K2_U01, K2_U18]

6. Student can plan and realize operating tests and prototype investigations of equipment appearing in environmental engineering (achieved during tutorials and laboratory exercises) - [K2_U01, K2_U18]

7. Student can determine an accuracy and analyse obtained results of calculation and measurements (achieved during tutorials and laboratory exercises) - [K2_U01, K2_U18]

8. Student can critically analyse obtained results of calculations and measurements and develop conclusions (achieved during lectures, tutorials and laboratory exercises) - [K2_U01, K2_U18]

Social competencies:

1. Student understand and appreciate a team cooperation in solving theoretical and practical problems (achieved during lectures, tutorials and laboratory exercises) - [K2_K03]

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) - [K2_K03]

3. Student understands a need of examination and verification of results of used calculation and experimental methods.(achieved during lectures, tutorials and laboratory exercises) - [K2_K03]

4. Student is aware of need of innovation (achieved during lectures, tutorials and laboratory exercises) - [K2_K03]

Assessment methods of study outcomes

Lecture (results W03, W04, W07, U01, U18)

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 (1 to 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 (results U01, U18)

60-minute written test at the end of semester (solution of of 1 or two 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.

Course description

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 method:

Classical lecture with elements of conversation

Tutorials ? solving problems method

Laboratory exercises ? teaching by experimentation.

Basic bibliography:

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 bibliography:

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

Result of average student's workload

Activity	Time (working hours)
1. Lectures (contact hours)	30
2. Participation in tutorials (contact hours, practical training)	30
3. Participation in laboratory training (exercises) (contact hours, practical training)	30
4. Preparation to tutorials (autonomus learning)	10
5. Development of laboratory reports and oral presentation (autonomus learning)	12
6. Consultations (contact hours)	3
7. Preparation to final tutorial test (autonomus learning)	10
8. Preparation to examination test and presence at the exam (autonomus learning and contact hours)	25

Student’s workload

Source of workload	hours	ECTS
Total workload	150	6
Contact hours	95	3
Practical activities	60	2