# STUDY MODULE DESCRIPTION FORM

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

**Responsible for subject / lecturer:**

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## Prerequisites in terms of knowledge, skills and social competencies:

| | | |
|---|---|---|
| 1 | **Knowledge** | Mathematics: 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. - [-] - [-]

2. Student knows basic methods needed for theoretical and design solution of thermal problems appearing in environmental engineering. - [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 - [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 - [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. - [K2_U01, K2_U18]

2. Student can find adequate relationships describing analysed heat processes. - [K2_U01, K2_U18]

3. Student knows how determine thermodynamic properties needed for heat and mass transfer calculations - [K2_U01, K2_U18]

4. Student can recognize and solve advanced design and operation heat and mass transfer problems occurred in heat equipment - [K2_U01, K2_U18]

5. Student can critically estimate a design solution and recognize a danger hazard in erected and operated heat equipment - [K2_U01, K2_U18]

6. Student can plan and realize operating tests and prototype investigations of equipment appearing in environmental engineering - [K2_U01, K2_U18]

7. Student can determine an accuracy and analyse obtained results of calculation and measurements - [K2_U01, K2_U18]

8. Student can critically analyse obtained results of calculations and measurements and develop conclusions - [K2_U01, K2_U18]

## Social competencies:

1. Student understand and appreciate a team cooperation in solving theoretical and practical problems - [- 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 - [- K2_K03]

3. Student understands a need of examination and verification of results of calculation and experimental methods - [- K2_K03]

4. Student is aware of need of innovation - [- K2_K03]

## Assessment methods of study outcomes

Lecture:

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.

Tutorials:

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.

## 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 | 30 |
| 2. Participation in tutorials | 30 |
| 3. Participation in laboratory training (exercises) | 30 |
| 4. Preparation to tutorials | 10 |
| 5. Development of laboratory reports and oral presentation | 12 |
| 6. Consultations | 3 |
| 7. Preparation to final tutorial test | 10 |
| 8. Preparation to examination test | 40 |

## Student’s workload

| Source of workload | hours | ECTS |
|---|---|---|
| Total workload | 130 | 6 |
| Contact hours | 78 | 3 |
| Practical activities | 77 | 3 |