Politechnika Warszawska

SZKOŁA DOKTORSKA PW NR 5 SYLABUS 2020/2021	
Nazwa przedmiotu	**Współczesne metody modelowania złożonych procesów wymiany ciepła**
Course name	Contemporary methods of modeling of complex processes of heat transfer
Liczba punktów ECTS	2
Wiodąca dyscyplina naukowa	Inżynieria środowiska, górnictwo i energetyka
Czy przedmiot może być oferowany dla studentów innych dyscyplin? (TAK / NIE)	TAK

	Stopnie, tytuł naukowy	**Imię i nazwisko**	**Wydział / Instytut / Katedra / Centrum/ Inne**
Osoba odpowiedzialna za przedmiot (koordynator)	Prof. dr hab.	Piotr Furmański	MEiL/ITC/Zakład Termodynamiki
Osoby planowane do prowadzenia zajęć	Prof. dr hab.	Jerzy Banaszek	MEiL/ITC/Zakład Termodynamiki
	Prof. dr hab. inż.	Piotr Furmański	MEiL/ITC/Zakład Termodynamiki
	Dr hab. inż.	Maciej Jaworski	MEiL/ITC/Zakład Termodynamiki
	Dr hab. inż.	Piotr Łapka	MEiL/ITC/Zakład Termodynamiki
	Dr hab. inż.	Mirosław Seredyński	MEiL/ITC/Zakład Termodynamiki

Semestr studiów	II (summer)
Typ przedmiotu (możliwości wyboru) obowiązkowy **O** fakultatywny **F**	F
Wymagania wstępne Zakres wiadomości / kompetencji / umiejętności, jakie powinien już posiadać student przed rozpoczęciem nauki przedmiotu, a także specyfikacja innych przedmiotów lub programów, które należy zaliczyć wcześniej.	Knowledge of the basic heat transfer and thermodynamics corresponding to the undergraduate level of studiem. Knowledge of partial differential equations icorresponding to the graduale level of studies
Poziom przedmiotu ~~Podstawowy **P**~~ ~~Średniozaawansowany **Ś**~~ Zaawansowany **Z**	**Z**

Charakter zajęć (wykład , ćwiczenia, projekty, laboratoria , warsztaty)	Wykład
Liczba godzin kontaktowych z prowadzącym	liczba godzin w semestrze 45 sugerowana liczba godzin w tygodniu 3
Liczba godzin pracy własnej studenta	przygotowywanie studenta do zajęć (wg indywidualnej potrzeby) przygotowywanie studenta do zaliczenia 45
Całkowita liczba godzin	90
Język wykładowy (PL / ENG)	ENG
Cel przedmiotu Opis zakładanych kompetencji i umiejętności, jakie student nabywa w wyniku zaliczenia przedmiotu. Uwaga: maksymalna objętość tekstu to 5 wierszy	Knowledge of the complex phenomena occuring in nature and met in engineering associated with energy transformations in which heat transfer is dominant. Ability of the mathematical description of these phenomena playing a significant role in a modern technological processes, classical and nuclear power engineering as well as in application of the renewable sources of energy, electrical, electronic and building eginineering, This description also allows to control many industrial process leading to increase in their higher effectiveness. Knowledge of the modelling methods, simplified models used and numerical simulation of the complex heat transfer processes.

Treść przedmiotu (jeżeli przedmiot będzie prowadzony w j. ang. proszę wypełnić po angielsku)

treści merytoryczne przedmiotu dla każdej składowej przedmiotu, tj. dla W; Ć; L; P.
Uwaga: maksymalna objętość tekstu to 1 standardowa strona A4.

1. Thermal radiation in semitransparent media emitting, absorbing and anisotropically scattering radiation. Description of the heat transfer phenomena via thermal radiation inside media and at their boundary. Radiation intensity. Radiative transport equation. Relation between intensity at the inerface of two media characterized by different value of the refraction index. Relation between radiation intensity and radiative heat flux. Diffusive approximation and radiative transfer in the transparent media. Solution methods of the radiative transport equation: S-N, P-N, Finite Volume Method, Ray and Monte Carlo methods. Methods of determination of the radiative properties and their wavelength dependence: narrow and wide bands approximation. Application of parallel comuting in solution of thermal radiation problems. Conjugated heat transfer via thermal radiation, heat convection and conduction. Thermal radiation and light propagation. Examples of application.
2. Heat transfer in the phase change processes. Ways of accounting for heat generation during phase change in the energy equation. Numerical simulation of the phase change. Metod of accounting for hysteresis in the enthalpy versus temperature relation during melting and solidification. Influence of the phase change on the intensity of heat transfer. Examples of modeling of phase change: frost formation in refrigeration, ice accretion of aircraft elements and wind turbine blades, storage of energy in the phase change materials (PCMs). Modeling of operation of temperature stabilizing devices using PCMs.
3. Heat transfer in suspensions and porous media. Mathematical description of heat transfer during flow of fluid suspensions and fluid flow through prous media. Thermodynamic equilibrium in suspensions and porous media. Dispersion phenomenon. Momentum equation for fluid flow through porous media accounting for Darcy and Brinkman terms. Boundary conditions at the fluid – porous medium interface. Numerical simulation of heat transfer in suspensions and porous media (Euler and Lagrange models). Filtration equation. Applications of suspensions and porous media in enhancement of heat transfer.
4. Microscale heat transfer. Energy carriers in solids and fluids. Mean free path of energy carriers. Effects of thermodynamic nonequilibrium. Phenomenon of thermal memory. Modeling of wave phenomena in heat transfer – hyperbolic heat conduction equation. Heat transfer with discontinuities in fluid velocity and temperature at the solid boundary, free-molecular flows. Ways of heat transfer modeling when the mean free path of the energy carriers is comparable with the medium dimensions. Examples of application.
5. Heat transfer in the two-phase flows. Mathematical description two-phase floks with accompanying heat transfer. Maps of flow structures and their determination. Modeling of the variation of the phase volume fraction, pressure drops and heat transfer for different flow structures. Critical two-phase flows. Examples of application.
6. Heat transfer in thermal protection of buildings. Heat and moisture flow through opaque envelopes. Conjugated heat transfer through the semi-transparent envelopes. Methods of modeling of environment interaction on heat transfer through building envelopes. Methods of reducing the heat transfer through

building envelopes via application of transparent and dynamic insulations as well as by using PCMs placed in the building structure. Methods of numerical simulation of transient heat transfer in buildings and thermal stability problem. Heat transfer in cities. 7. Inverse problems in heat transfer. Categorization: determination of thermal properties, boundary and initial conditions, location of heat sources, object geometry, in which heat transfer occurs. Sensitivity coefficients. Methods of solution of the inverse heat transfer problems: parameter or function estimation, regularization (Tichonow regularization, iterative procedures, self-regularization). Criteria satisfied by the methods used for solution of the inverse problems. Gradient and nongradient techniques.

Spis zalecanych lektur	
1.	Incropera F.P., Dewitt D.P., Bergman T.L., Lavine A.S.: *Principles of Heat and MassTransfer*, John Wiley &Sons, różne wydania
2.	Naterer G.F: *Advanced Heat Transfer*, CRC Press, Taylor and Francis Group, 2018
3.	Bejan A., Kraus A.D. (ed.): *Heat Transfer Handbook*, John Wiley & Sons INc., 2002
4.	Kaviany M.: *Principles of Heat Transfer in Porous Media*, Springer-Verlag, 1995
5.	Tzou D.Y.: *Macro- to Microscale Heat Transfer*, Taylor & Francis , 1997
6.	Ozisik, M.N. and Orlande, H.R.B.: *Inverse Heat Transfer: Fundamentals and Applications*, Taylor and Francis, NY., 2000

Metody oceny (ocena, egz. pisemny, egz. ustny, projekt)	Numerical project, test

Uwagi dodatkowe	

Tabela 1. Efekty kształcenia

Numer (symbol)	Efekty kształcenia słuchacza, który zaliczył przedmiot, potrafi	Sposób weryfikacji osiągnięcia efektu
	WIEDZA	
WISGE_32_01	The student will have an advanced knowledge in the selected area of heat transfer, applicable to formulating and solution of complex problems associated with environment engineering, mining and power engineering or other fields in which heat transfer plays an important role.	Test from lecture material
	UMIEJĘTNOŚCI	
UISGE_32_01	The student is able to use mathematical tools used in modelling processes and solutionof the research problems in environment engineering, mining and power engineering or other fields in which heat transfer plays an important role.	Numerical project
	KOMPETENCJE	
KISGE_32_01	It will be also able to present results of his/her own research obtained with use of the heat transfer modelling methods.	Presentation of the project