Mathematical approaches in description of turbulent flows -
– COURSE SYLLABUS

1.	**Course title:** *Mathematical approaches in description of turbulent flows*	
2.	**Lecturer:** *Krzysztof Mizerski*	
3.	**Field, type and level of studies, year of study:** *Fluid dynamics, all years*	
4.	**Course character:** *monographic lecture*	
5.	**Teaching method:** *traditional*	
6.	**Language:**	*English (or Polish, depending on the audience)*
7.	**Course type and number of hours:** *Lecture 30h*	
8.	**Estimated load of student's independent work:**	*50h*
9.	**Total workload and number of ECTS points:**	*3 ECTS*
10.	**Short description and main focus of the course:** *1. The basic concepts.* *a) The equations of hydrodynamics, averaging and Reynolds decomposition,* *b) The Reynolds stress and its effect on large scale flows; turbulent viscosity* *2. The simplest theory of weak turbulence and calculation of the Reynolds stress* *3. Strong turbulence – fully nonlinear* *a) General description of isotropic and axisymmetric turbulence from symmetry considerations and group theory,* *● The energy cascade* *● The evolution equations for the correlation tensor* *b) The Markovianized one-point two-scale approach,* *c) Renormalization of the hydrodynamic equations,* *● Turbulent viscosity and large-scale flow* *d) The Two-Scale Direct Interaction Approach (TSDIA),* *e) The stochastic description of the dynamics of particle trajectories, passive scalars and streamlines.*	

11.	**References:** *Literature: The lecture will not be fully based on any particular book and its aim will be to present mathematical methods applied to describe complex, nonlinear turbulent flows in an accessible form. Therefore, there is no single textbook, but the recommended literature includes (will be sent to students in electronic form):* *[1] A. Yoshizawa 1998, Hydrodynamic and magnetohydrodynamic turbulent flows, Springer.* *[2] G.K. Batchelor 1982, The theory of homogeneous turbulence, Cambridge University Press.* *[3] P.A. Davidson 2015, Turbulence: an introduction for scientists and engineers, Oxford University Press.* *[4] W.D. McComb 2014, Homogeneous isotropic turbulence; phenomenology, renormalization and statistical clossures, Oxford University Press.* *[5] K. Gawędzki 2008, Soluble models of turbulent transport, in: Non-equillibrium statistical mechanics and turbulence by J. Cardy, G. Falkovich & K. Gawędzki, Cambridge University Press.*	
12.	**Prerequisites:** *1. Knowledge of the theoretical basics of hydrodynamics.* *2. Knowledge of the basics of statistics.* *3. Good knowledge of vector calculus* *4. Knowledge of methods for solving differential equations.*	
13.	**Educational outcomes:**	**PQF level 8 codes:**
	Knowledge: *Students know and understand the world's achievements in modelling of turbulent flows and the resulting implications of this for practical solutions.*	*P8U_W*
	Practical Skills: *Students are able to analyse and creatively synthesise scientific and creative achievements to identify and solve research problems as well as those related to innovative and creative activities. Also they are able to contribute new elements to these achievements, independently plan their own development as well as inspire the development of others. Additionally they participate in the exchange of experiences and ideas, also in the international community.*	*P8U_U*
	Social Skills: *Students are ready to conduct independent research which contributes to existing scientific and creative achievements in theory of the turbulent flow, assume professional and public challenges concerning this field of knowledge.*	*P8U_K*
14.	**Evaluation of the educational outcomes:** *oral exam*	
15.	**Criteria to complete the course:** *At least grade 3 on the final exam.*	
16.	**Contact with the lecturer:** *kamiz@igf.edu.pl*	