



Subject card

Subject name and code	Biofluids, PG_00057493						
Field of study	Mechanical and Medical Engineering						
Date of commencement of studies	February 2023	Academic year of realisation of subject				2023/2024	
Education level	second-cycle studies	Subject group				Obligatory subject group in the field of study Subject group related to scientific research in the field of study	
Mode of study	Full-time studies	Mode of delivery				at the university	
Year of study	1	Language of instruction				Polish	
Semester of study	2	ECTS credits				2.0	
Learning profile	general academic profile	Assessment form				assessment	
Conducting unit	Department of Energy and Industrial Apparatus -> Faculty of Mechanical Engineering and Ship Technology						
Name and surname of lecturer (lecturers)	Subject supervisor		prof. dr hab. inż. Krzysztof Tesch				
	Teachers		prof. dr hab. inż. Krzysztof Tesch				
Lesson types and methods of instruction	Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
	Number of study hours	15.0	0.0	15.0	0.0	0.0	30
	E-learning hours included: 0.0						
Learning activity and number of study hours	Learning activity	Participation in didactic classes included in study plan		Participation in consultation hours		Self-study	SUM
	Number of study hours	30		3.0		17.0	50
Subject objectives	Provide general knowledge on bioflows						
Learning outcomes	Course outcome		Subject outcome			Method of verification	
	[K7_W03] He/she knows methods, techniques and tools applied to solve engineering problems in the scope of the field of study of mechanical-medical engineering		The student knows methods, techniques and tools used to solve engineering tasks in the field of mechanical-medical engineering			[SW1] Assessment of factual knowledge	
	[K7_W04] He/she has in-depth knowledge related to the construction and utilization of machines used mechanical-medical engineering		The student has in-depth knowledge of selected problems in the field of mechanical engineering and operation of machines useful in mechanical-medical engineering			[SW1] Assessment of factual knowledge	
	[K7_U05] He/she can use measurement technique and methods to assess errors of measurement. He/she can plan and conduct research (also numerical ones) and interprets obtained results and draw conclusions		The student is able to use measurement apparatus and methods of measurement error estimation, plan and conduct experiments (including computer simulations), critically interpret the obtained results and draw conclusions			[SU4] Assessment of ability to use methods and tools	
Subject contents	<p>LECTURES General form of conservation equation. Constitutive equation for newtonian fluids (air) and non-newtonian (blood). Special form of conservation equations. Boundary and compatibility conditions. Blood vessels. Murray's laws. Fractal dimension of vessel structure. Characteristics of blood. Selected analytical solutions for tube flows. Electrical-mechanical analogy for blood flow. Introduction to turbulence in respiratory system. Flows with heat transfer.</p> <p>LABORATORY Learning of the basic features of the software for numerical simulation of flows. Comparison of analytical and numerical solutions for selected equations of blood models. Reconstruction of example bifurcation geometry on the basis of MRI data. Numerical simulation of blood flow through reconstructed geometry. Numerical simulation of air flow through chosen geometry.</p>						

Prerequisites and co-requisites	Fluid Mechanics. Mathematics.		
Assessment methods and criteria	Subject passing criteria	Passing threshold	Percentage of the final grade
	test	50.0%	100.0%
Recommended reading	Basic literature	<p>Tesch K., "Mechanika Płynów", Wyd. PG, 2008, 2013</p> <p>Tesch K., "Wybrane Zagadnienia Modelowania Przepływów Krwi...", Wyd. PG, 2012</p> <p>Bębenek B., "Przepływy w układzie krwionośnym" Wyd. PK, 1999</p> <p>Cieśllicki K., "Hydrodynamiczne uwarunkowania krążenia mózgowego", Wyd. EXIT, 2001</p>	
	Supplementary literature	Puzyrewski R., Sawicki J., "Podstawy Mechaniki Płynów i Hydrauliki", PWN, 1998	
	eResources addresses	<p>Adresy na platformie eNauczanie:</p> <p>Bioprzepływy, W/L, IMM, sem. 2, zimowy 23/24 (PG_00057493) - Moodle ID: 32378</p> <p>https://enauczanie.pg.edu.pl/moodle/course/view.php?id=32378</p>	

<p>Example issues/ example questions/ tasks being completed</p>	<ol style="list-style-type: none"> 1. What is the closed system of equations that describes blood flow as a Newtonian fluid. What are the names of all equations and symbols? 2. What is the closed system of equations that describes blood flow as a non-Newtonian fluid. What are the names of all equations and symbols? 3. What is the difference between the Newtonian and non-Newtonian model of fluid? 4. What is the general classification of non-Newtonian fluids? 5. Describe the Ostwald-de Waele model. What are the names and meaning of all symbols? 6. Describe the Herschel-Bulkley model. What are the names and meaning of all symbols? 7. Describe the Casson model. What are the names and meaning of all symbols? 8. Describe any rate type fluid. What are the names and meaning of all symbols? 9. What are the blood features. Is it a Newtonian fluid? Why? 10. Describe Poiseuille's law. What are the names of all symbols? Where does it come from? 11. Is the velocity profile in a circular cross section the same for a Newtonian and non-Newtonian fluid? Why? 12. What does Womersley's solution/equation describe? 13. What is the mechanical-electrical analogy? What are the relationships among mechanical and electrical quantities/functions? 14. Draw electrical circuit describing an elastic artery with leakage. What is the system of equation for this circuit? What are the names and meaning of all symbols? 15. Draw electrical circuit describing a rigid artery without leakage. What is the system of equation for this circuit? What are the names and meaning of all symbols? 16. Derive Murray's law. What is the interpretation of this law? 17. How to estimate the total number of bifurcations and arteries by means of Murray's law? 18. What are the configurations/structures of arteries? For which structure is Murray's law valid?
<p>Work placement</p>	<p>Not applicable</p>

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