Warsaw University
of Technology

COURSE OFFERED IN THE DOCTORAL SCHOOL

Code of the course	4606-ES-00000BH-0186	Name of the course	Polish	**Złożone modelowanie matematyczne dynamiki lotu kierowanych pocisków rakietowych**
			English	**Complex mathematical modeling of the guided missiles flight dynamics**

Type of the course	specialized				
Course coordinator	dr hab. inż. Robert Głębocki prof. PW				
Implementing unit		Scientific discipline / disciplines*	Mechanical Engineering/Automation, Electronics and Electrical Engineering and Space Technologies/		
Level of education	Postgraduate	Semester	summer		
Language of the course	English				
Type of assessment:	project or laboratory report	Number of hours in a semester	24	ECTS credits	3
Minimum number of participants	10	Maximum number of participants	20	Available for students (BSc, MSc)	Yes

Type of classes		Lecture	Auditory classes	Project classes	Laboratory	Seminar
Number of hours	in a week	2		2		
	in a semester	12		12		

* does not apply to the Researcher's Workshop

1. Prerequisites

Basic knowledge of mathematics incl. numerical methods, mechanics, automatic control theory, aerodynamics and flight dynamics, rocket propulsion. Knowledge of these issues at the engineering level.

2. Course objectives

The goal of the course is to study the methodology of creating a complex mathematical model of the flight of a guided missile and the operation of its control system.

3. Course content (separate for each type of classes)

Lecture

1. Overview of the approach to build a complex model using MATLAB and Flightgear;
2. Modeling of aerodynamic phenomena in the range of subsonic, transsonic and supersonic velocities;
3. Models of rocket and jet engines for quick calculation of parameters;
4. Electrohydraulic, pneumatic and electric steering drives and methods of their modeling;
5. Guidance laws and modeling of navigation, guidance and control systems;
6. Visualization of calculation results and comparison with data from flight tests;

Laboratory

1. Modeling of aerodynamic characteristics by means of MissileDATCOM and creation of a subsystem of the model of the aerodynamics
2. Creation of a rocket engine model with thrust vector control
3. Development of a set of steering drive models with different levels of the modeling phenomena
4. Creation of a submodel of the target's movement, the operation of the navigation, guidance and the control systems
5. Integration of submodels into complex model and development the visualization system
6. Determination of the probability of interception by the Monte Carlo method

4. Learning outcomes			
	Learning outcomes description	Reference to the learning outcomes	Learning outcomes verification

		of the WUT DS	methods*
Knowledge			
K01	Knowledge of the role of the mathematic modeling in the development cycle of the guided missiles.	DS_K1	written test
K02	Knowledge of individual subsystems of guided missiles and rules to create their models. Knowledge of the impact of individual subsystems characteristics on the functioning of the entire system with guided missile	DS_K2	written test
K03	Knowledge on the pathway to determine the integral characteristics of the system with guided missile by Monte Carlo method	DS_K3	written test
Skills			
S01	Ability to include the model development in the design process of the system with guided missile.	DS_S1	project evaluation
S02	Ability to formalize design requirements and create mathematical models of guided missile subsystems on base of incomplete information of the initial design stage	DS_S2	project evaluation
S03	The ability to plan a numerical experiment to obtain integral characteristics	DS_S3	project evaluation
Social competences			
SC01	competence in leading the engineering teams	DS_SC1	written test

*Allowed learning outcomes verification methods: exam; oral exam; written test; oral test; project evaluation; report evaluation; presentation evaluation; active participation during classes; homework; tests

5. Assessment criteria
Project evaluation and oral test

6. Literature

[1] Eugene L. Fleeman, “Tactical Missile Design”, American Institute of Aeronautics & Astronautics, 2022, ISBN: 9781624106187

[2] Paul Zarchan, “Tactical and Strategic Missile Guidance”, American Institute of Aeronautics & Astronautics, 2019, ISBN: 9781624105845

7. PhD student’s workload necessary to achieve the learning outcomes**		
No.	Description	Number of hours
1	Hours of scheduled instruction given by the academic teacher in the classroom	24
2	Hours of consultations with the academic teacher, exams, tests, etc.	5
3	Amount of time devoted to the preparation for classes, preparation of presentations, reports, projects, homework	36
4	Amount of time devoted to the preparation for exams, test, assessments	10
	Total number of hours	**75**
	ECTS credits	**3**

** 1 ECTS = 25-30 hours of the PhD students work (2 ECTS = 60 hours; 4 ECTS = 110 hours, etc.)