

**COURSE OFFERED IN THE DOCTORAL SCHOOL**

Code of the course	4606-ES-00000BH-0127	Name of the course	Polish	Układy nawigacyjne		
			English	Navigation systems		
Type of the course	Specialized subject					
Course coordinator	Prof dr hab. inż. Janusz Narkiewicz					
Implementing unit	Faculty of Power and Aeronautical Engineering	Scientific discipline / disciplines*	Mechanical engineering /Automation Electronics			
Level of education	PhD studies	Semester	summer			
Language of the course	English					
Type of assessment:	Final mark based on test, project and presentations qualities	Number of hours in a semester	30	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	3 weeks 6 hours and 1 week 1 hour		Individual consultations compulsory		Project presentations (presence compulsory)
	in a semester	20		6		4

\* does not apply to the Researcher's Workshop

**1. Prerequisites**

Fundamental knowledge and skills in mathematic (matrix calculus, ordinary differential equations, stochastic methods) and in mechanics (dynamics).

**2. Course objectives**

To comprehend models and mathematical methods used in navigation and attitude systems and their applications to various mobile platforms (land, water, air, space).

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

**Lecture**

Methods for position and attitude determination. Architectures of the position and attitude systems. Sensors and their errors. Accelerometers. Gyroscopes. Earth shape and systems of coordinates. Earth gravity and gravity sensors. GNSS. Inertial Navigation Systems. INS/GPS integration.

Supervised project: to develop a model and an algorithm for selected navigation / attitude system.

**Laboratory**

**4. Learning outcomes**

	Learning outcomes description	Reference to the learning outcomes of the WUT DS	Learning outcomes verification methods*
Knowledge			
W01	She / he knows the background of the methods, sensors, errors of navigation and attitude systems, sensor integration and data fusion.	SD-W3	Test
Skills			

U01	She / he is capable to develop mathematical and simulation model of the system containing various sensors and various data processing algorithms.	SD-U1	Report evaluation
Social competences			
K01	Clear and comprehensive communication and presentation of own achievements.	SD-K1, SD-K4	Report evaluation Presentation evaluation

\*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

The sum of partial achievements

Total mark= Test\*0,4+Project results and report\*0,4+Presentation (seminar)\*0,2

#### 6. Literature

##### Background

[1] Grewal M.S., Weill L.R., Andrews A.P., "Global Positioning Systems, Inertial Navigation and Integration", John Willey & Sons, 2000.

[2] Lawrence A., "Modern Inertial Technology. Navigation, Guidance, and Control". Springer-Verlag, 1998

[3] Rogers R.M., "Applied Mathematics in Integrated Navigation Systems", AIAA Series, 2000.

web site materials

##### Supplementary

Literature will be given for each lecture based on relative chapter of the text / monography book. Books should be available in university or faculty library. Specialized literature references will be given for the projects.

#### 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	30
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	30
4	Amount of time devoted to the preparation for exams, test, assessments	10
<b>Total number of hours</b>		<b>75</b>
<b>ECTS credits</b>		<b>3</b>

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