Description of course	
Code of course	**1160-TR000-MSA-0201**
Name of course	***Stochastic Processes***
Version of course	2021/22
A. *Place of the course in system of studies*	
Level of education	*Second-cycle degree*
Form and mode of studies	*Full-time studies*
Field of studies	*Transport*
Profile of studies	*General academic profile*
Specialization	*Subject common for the course*
Place of teaching of course	*Warsaw University of Technology, Faculty of Transport, Division of Informatic Systems and Mechatronics in Transport*
Place of realization of course	*Not applicable*
Coordinator of course	*D. Eng. Maciej Kozłowski, university professor, Division of Informatic Systems and Mechatronics in Transport, Faculty of Transport, Warsaw University of Technology*
B. *General characteristic of the course*	
Group/*Block of courses*	*Basic subjects*
Level of course	*Advanced level*
Type of course	*Obligatory subject*
Language of course	*English*
Location of the course in the study plan – nominal semester	*2*
Location of the course in the academic year	*summer semester*
Preliminary requirements - formal	*no*
Limit of students	*Lecture: 100 students, computer classes: 15 students*
C. *Effects of education and manner of teaching*	
Purpose of course	*Master the basic concepts of stochastic process theory (time series and random fields). Acquiring the ability to determine the basic characteristics of stochastic processes with particular emphasis on numerical techniques. Understanding the basic equations that take into account stochastic processes.*

Effects of education with reference to the learning outcomes for the area and field of study

No. effect	***Description of the effect***	***Reference to the characteristics of learning outcomes***	***Reference to the learning outcomes in the program***
Assumed learning outcomes in terms of knowledge			
W01	*Has a basic knowledge of stochastic processes. He knows symbols, basic concepts and theorems as well as examples of stochastic processes.*	*I.P7S_WG.o*	*Tr2A_W01*
W02	*He knows the basic applications of the theory of stochastic processes in the analysis of signals.*	*I.P7S_WG.o*	*Tr2A_W01* *Tr2A_W10*
W03	*He knows the rules of inference under conditions of uncertainty in the field of application of dynamic Bayesian networks to direct transport systems.*	*I.P7S_WG.o*	*Tr2A_W01* *Tr2A_W10*
Assumed learning outcomes in terms of skills			
U01	*He can formulate and solve simple problems of applying the theory of stochastic processes.*	*I.P7S_UW.o* *III.P7S_UW.o*	*Tr2A_U03*
U02	*He can use information from literature and use Internet databases*	*I.P7S_UW.o*	*Tr2A_U01*
Assumed learning outcomes in the field of social competences			
KS01	*Understands the need for continuous training and refreshing the acquired knowledge, in particular in the field of stochastic processes.*	*I.P7S_KK*	*Tr2A_K01*

Form of didactic studies and number of hours	*Lecture*	*Exercise*	*Laboratory*	*Project*	*Computer classes*
On a weekly plan	1	0	0	0	1
Throughout the semester	15	0	0	0	15

Contents of education - separately for each form of didactic studies	***Lectures:*** *Basic information (2 h). Definition of a stochastic process (measurable probabilistic space, time series and random fields, chains, stationary processes / in the narrow and broad sense /, ergodic processes). Fourier transform, Characteristics of a stochastic process (in the time and frequency domain).* *Some types of stochastic processes (3 h). Bernoulli processes, Wiener process, Markov processes (where states in the immediate future depend only on the current state), Poisson processes, Gaussian processes: processes where all linear combinations of coordinates are random variables with normal distribution, branch process, Brownian motion, white noise.* *Selected equations and theories related to stochastic processes (5 h). Prospective Chapman-Kolmogorov-Planck equation; Dynamic Bayesian networks, Dempster-Shafer theory, Simple and inverse Kramers-Moyal equations, ITO equations* *Sampling and filtering of stochastic processes. Continuity definition. Examples of applications of stochastic processes in transport. Reasoning under uncertainty. Hidden Markov processes. Kalman filters (5 h).* ***Computer classes:*** *The computer exercises include 7 two-hour exercises from the lecture material. They will be implemented on platforms such as DasyLab, LabView or Matlab. The scope of the exercises includes the material provided during the lectures.*
Teaching methods	***Lectures:*** *multimedia presentation.* ***Computer classes****: solving tasks using specialized computational software such as: DasyLab, LabView, Matlab, Statistica, Octave Python or R.*

Methods of verification of effects of education

No. effect	***Methods of verification***
	Assumed learning outcomes in terms of knowledge
W01	*2 open-ended questions on a written test, at least 50% response to each question is required.*
W02	*2 open-ended questions on a written test, at least 50% response to each question is required.*
W03	*2 open-ended questions on a written test, at least 50% response to each question is required.*
	Assumed learning outcomes in terms of skills
U01	*Credit for computer exercises. Prerequisites for passing is at least the proper realization of the exercise in terms of content, making a report and showing the basic knowledge necessary for its implementation.*
U02	*Credit for computer exercises. Prerequisites for passing is at least the proper realization of the exercise in terms of content, making a report and showing the basic knowledge necessary for its implementation.*
	Assumed learning outcomes in the field of social competences
KS01	*Participate in class discussion, correct statement of effect required.*

Methods of evaluation	***Lecture*** *Summative assessment: 1 written test containing a total of 6 open-ended questions (2 questions for each knowledge effect). At least 50% correct answers to each of them are required.* ***Computer classes:*** *Formative assessment: Computer assignments to be worked out independently. At least 50% of correct answers are required. Integrated assessment (arithmetic mean of lecture and exercises).* *Integrated assessment:* *Weighted average of the grades from lecture and project (weight of lecture 0.33; exercises 0.67).*
Exam	*No*

Literature	*Basic literature*: *1) Bendat Julius S.: Methods of analysis and measurement of random signals - first edition, WNT, Warsaw 1976.* *2) Wentzell A.D.: Lectures on the theory of stochastic processes, PWN, Warsaw 2000.* *3) Plucińska A., Pluciński E.: Probabilistyka. Mathematical statistics. Stochastic processes. Probability calculus, PWN, Warsaw 2017.* *4) Lipcer R.Sz., Shiriaev A.N.: Statistics of stochastic processes: nonlinear filtration and related issues, PWN, Warsaw 1981.* *Supplementary literature:* *1) Papoulis A.: Probability, Random Variables and Stochastic Processes 4th Edition, Amazon 2012.* *2) Bouleau N., Lepingle D.: Numerical methods for stochastic processes, John Wiley & Sons, 1993.* *3) Brzezniak Z., Zastawniak T.: Basic stochastic processes. A course through exercises, Springer-Verlag, London 2002.*
Website of the course	https://moodle.usos.pw.edu.pl/
D. ***Student's activity***	
Number of ECTS credits	2
Number of hours of student's work to achieve effects of education	*59 hours, including: the work at the lectures 15 hours, work at the computer classes 15 hours, study of the subject literature and preparation for the colloquium in the lecture 10 hours, preparation for the colloquium in the computer classes 16 hours, consultations 3 hours (including consultations in the computer classes 2 hours).*
Number of ECTS credits on the course with direct participation of academic teacher	*1.5 of ECTS credits (33 hours, including: work in the lectures 15 hours, work in the computer classes 15 hours, consultations 3 hours).*
Number of ECTS credits on practical activities on the course	*1.5 of ECTS credits (33 hours, including: work on computer classes - 15 hours, preparations for colloquia - 16 hours, consultations - 2 hours).*
E. ***Additional information***	
Notes	*As long as it does not cause changes in the relationship of a given subject with the directional effects in the content of education, changes may be introduced on an ongoing basis, taking into account the latest scientific achievements.*
Date of last edition	*2021-02-09 23:35*