Ministry of Science and Higher Education of the Russian Federation
Federal State Autonomous Educational Institution of Higher Education
Perm National Research Polytechnic University

APPROVED BY
Pro-rector for Academic Affairs
_____ N.V. Lobov
"25" _____ 2021

ACADEMIC COURSE WORKING PROGRAM

Academic course: Fundamentals of identification
(Name)

Form of education: Full-time studies
(Full-time /full-time - correspondence/correspondence)

Level of higher education: Bachelor's program
(Bachelor's program/specialist program/Master's program)

Workload in hours (in credits): 216 (6)
(Hours (CU))

Training program (degree): 15.03.06 Mechatronics and robotics
(Code and denomination of degree)

Direction: Mechatronics and Robotics
(Title of curriculum)

Perm 2021

1. General Provisions

1.1. Goals and Objectives of the Course

1. The goal of the course is to study methods and algorithms of secondary information processing in different conditions of observation dynamic objects, different models of input signals and different levels of prior uncertainty.
2. The goal of the course is to form the skills of the suboptimal algorithms' synthesis of the secondary signal processing problem solving, the analysis of its quality and computational efficiency.

1.2. Prescribed Objects of the Course

Mathematical methods of the autocontrol system description;
Basic approaches to the identification problem solving;
Basic methods of parametric identification;
Estimation methods of design models' adequacy to the source objects;

1.3. Starting Conditions

Discrete mathematics and logic theory

2. Planned Results of the Course Training

Competence	Indicator's Index	Planned Results of the Course Training (to know, to be able, to master)	Indicator of Attaining Competence which the planned results of training are correlated with	Means of Assessment
GPC-4	**IA-1$_{gpc-4}$**	**To know** basic methods and algorithms, optimal and suboptimal, secondary signal processing problems solving using ECM, observing dynamic objects with the help of multiline measuring tools.	**Knows** the rules of methods development for conducting research by working objects of mechatronics and robotics.	Grading test
GPC-4	**IA-2$_{gpc-4}$**	**To be able to** apply methods and algorithms, developing computing systems' application software, used for analysis and processing of input signals. Use of standard definitions, formulations and notations.	**Is able to** make experiments and process research results.	Individual task

GPC-4	**IA-3gpc-4**	**To master the skills** of data processing, received with the help of experiments on the basis of optimal and suboptimal methods and algorithms.	**Has mastered the skills** of processing the results of experiments on the base of modern information technologies and technical facilities.	Report on practice

3. Full time and forms of academic work

Form of academic work	Hours in all	Distribution in hours according to semesters
		Number of semester
		7
1. Holding classes (including results monitoring) in the form: 1.1. Contact classwork, including:	72	72
- lectures (L)	36	36
- laboratory work (LW)	16	16
- practice, seminars and/or other seminar-type work (PW)	18	18
- control of self-work (CSW)	2	2
- test paper		
1.2. Students' self-work (SSW)	108	108
2. Interim/midterm assessment		
Exam	36	36
Grading test		
Test		
Course Project (CP)		
Course Work (CW)		
Workload in hours	**216**	**216**

4. Course contents

Course units with brief contents	Full time of classroom activity in hours according to the forms			Full time of extracurricular work in hours according to the forms
	L	LW	PW	SSW
7^{th} semester				
Models of the signals. Bayesian problem definition of the secondary signals processing.	8	4	4	25
Model of dynamic object. Stochastic equation of dynamics. Markov's process. Measuring tools – reviewing and following, characteristics. Discrete observations. Measurement models from objects and noise measurements. Measurements' mistakes – fluctuating and				

systematic. Detection function. Models' aprior uncertainty: parametric and nonparametric uncertainties. Bayes decision rules for the secondary processing poblems; the necessity of full random models' specification. The ways of overcoming aprior uncertainty: generalization of stochastic models, analysis of the measurements' accordance (identifications) hypothesis, introduction of the aprior parameters' distribution. The ideas of adaptive decision rules. Aprior random models' specification with the known objects' quantity. Different loss functions for the secondary processing problems. Two-stage recurrence scheme of the secondary processing. Identification functional. Calculating of aposterior probabilities and undoubted aposterior densities. Suboptimal algorithms of reducing hypothesis searching.				
Aposterior analysis of the objects' flow	8	4	4	25
Data from the theory of stochastic flows. Flows of the indiscernible points, flows' densities, generating functionals. Poisson input, its intensity. Bernoullian input, partial flow, degenerate case. The flows of classified and grouped points. Flow- oriented model of the moving indiscernible objects. Partial measurement flow from one object. The flow of indiscernible noise measurements. Formalization of a measurement information secondary processing problem in Bayesian formulation. The problem of aposterior objects' flow analysis – calculating of aposterior flow densities according to the hypothesis of identification. The sense of hypothesis generation of measurement identification in indiscernible objects. Two-stage recurrent procedure of aposterior analysis in standard form. Aposterior analysis as a core of all the secondary processing problems. Calculating of aposterior probability of the identification fundamentals. Functional of the identification. Different loss functions. Undetermined parameters of the models' flow, averaging according to undetermined parameters.				
Problem solving procedures of the secondary signal processing	8	4	4	25
ECM resource requirements, deciding problems of the secondary processing. The necessity of standard computing circuit decomposition. Three objects' models with the independent conditions (Poisson and Bernoullian inputs,				

classified Bernoullian random walk). Quasi-determinateness of the parameters as the sufficient condition of aposterior analysis computational scheme decomposition. Examples of the decomposed computational schemes; going back to standard density distributions. Approach "with the averaging" of hypothesis probabilities; conjugate families of aprior parameters' distribution. Approach "with estimation" of unknown parameters. Maximum-likelihood technique.				
Algorithms of measurements identification and estimation of linear Gaussian objects' conditions	8	4	4	25
Linear Gaussian objects' models, measurements and unknown parameters. The problem of the likelihood function evaluation as a part of identification functional. Gaussianity of aposterior conventional density. Algorithm's synthesis of aposterior analysis as a collection of the small size Kalman filters. Decomposition of the extended Kalman filter in quasi-determined parameters. Algorithms for computing of undoubted objects state estimation; its suboptimal modifications. Linearization of the non-linear models.				
Combinatorial algorithms of the multiple measurements' identification	4	0	2	8
Measurements' identification as the problem of discrete optimization. Geometrical growth of the hypothesis number. Nonlinear nature of the identification functional. Suboptimal methods for reducing hypothesis searching. Measurement's strobing. "Moving window method". "In-frame" and "interframe" identification. Bringing the problem of in-frame identification to the familiar effective problems' decisions: problem of allocation and the minimum value flow problem. Algorithms' difficulty of in-frame identification problem solving. The problem of interframe identification. Tree of hypotheses. Algorithm with the fixed number of hypotheses. Algorithm based on the branch and bound method.				
Total with regard to 7^{th} semester	36	16	18	108
Total with regard to the course	36	16	18	108

Topics of exemplary practical work

№	Topic of practical (seminars) work
1	Models of the signals.
2	Aposterior analysis of the objects' flow.
3	Methods of secondary processing problems solving.
4	Algorithms of the measurement identification and estimation of the linear Gaussian objects

	condition.
5	Combinatorial algorithms of multiple measurements' identification.

Topics of exemplary laboratory works

№	Topic of laboratory work
1	Bayesian formulation of a secondary signal processing problem.
2	Undetermined parameters of the flow models, averaging according to undetermined parameters.
3	Adaptive measurements' identification.
4	Linearization of the non-linear models.

5. Organizational and Pedagogical Conditions

5.2. Educational Technologies Used for Competences Formation

Holding lectures in the discipline is based on the active method of training in the process of which students are not passive but active participants of the lesson answering questions of the teacher. Teacher's questions are aimed at activating the process of learning material as well as at the development of logical thinking. The questions stimulating associative thinking and connecting new material with the previous one are identified by the teacher in advance.
Practical lessons are held by realization of the method based on active training: problem areas are determined, groups are formed. The following aims are pursued in the process of practical education: use of definite disciplines, knowledge and creative methods in solving problems and decision-making; students' skill-building of teamwork, interpersonal communication and development of leadership skills; consolidation of the basic theoretical knowledge.
Laboratory classes are based on an interactive learning method in which students communicate not only with the teacher but also with each other. At the same time, students ' activity in the learning process dominates. The teacher's place in interactive classes is reduced to orienting students ' activities to achieve the goals of studies.
Interactive lectures, group discussions, role-playing games, training sessions, and analysis of situations and simulation models are used in academic studies.

5.3. Students' Manual for the Course Study

Learning the course, it is advisable for students to implement the following recommendations:
1. Learning of the discipline should be done systematically.
2. After learning one of the course units with the help of the text-book or lecture notes it is recommended to reproduce the basic terms, definitions, notions of the unit from memory.
3. Special attention should be paid to the reports on practical studies and individual complex tasks for self-work.
4. The topics list for individual study is given by the teacher at the lectures. The teacher also provides students with literary sources (first of all, new ones in the periodical scientific literature) for a more detailed understanding of the issues presented at the lectures.

6. List of Teaching Materials and Information Supply for Students' Self work in the Discipline

6.2. Paper-based courseware

№	Bibliographic entry (author, title, mode of publication, place, publishing house, year of publication, number of pages)	Number of copies in the library

1. Basic literature		
1	Tangirala K. Principles of system identification. Theory and practice/ Boca Raton Publ., 2015.	0
2	Diniz P. S. R., Suykens J. S. K., Chellappa R., Theodoridis S. Academic Press Library in Signal Processing: Volume 1 — Signal Processing Theory and Machine Learning (pp.113-168), Chapter: 4, Publisher: Elsevier, 2014.	0
2. Additional literature		
2.1. Educational and scientific literature		
1	Mohinder S. Grewwal, Andrews A. Kalman filtering: theory and practice using MATLAB/ InTechOpen Publ., 2018.	0
2	Pratap R., Ruina A. Statics and Dynamic/Oxford University Press Publ., 2001.	0
2.2. Periodical literature		
	Not used	
2.3. Standardized and Technical literature		
	Not used	
3. Students' manual in mastering discipline		
	Not used	
4. Teaching and learning materials for students' self-work		
	Not used	

6.3. Electronic Courseware

Kind of literature	Name of training tool	Reference to information resource	Accessibility of EBN (Internet/local net; authorized/free access)
Additional literature	MATLAB data	http://docs.exponenta.ru/	authorized/free access

6.3. License and Free Distributed Software used in the Course Educational Process

Type of Software	Software branding
Operating systems	MS Windows 8.1 (Azure Dev Tools for Teaching)
Office applications	Adobe Acrobat Reader DC, free software for PDF
Office applications	Microsoft Office Professional 2007. License 42661567
General purpose application software	Dr.Web Enterprise Security Suite, 3000 license, PNRPU RCI 2017

6.4. Modern Professional Databases and Inquiry Systems Used in the Course Educational Process

Branding	Reference to information resource
Scientific Library of Perm National Polytechnic Research University	http://lib.pstu.ru/
Lan' Electronic library system	https://eJanbook.com/
IPR books Electronic library system	http://www.iprbookshop.ru/
Information resources of Consultant+ web	http://www.consultant.ru/
Database EDSCO company	http://www.ebsco.com/

7. Logistics of the Course Educational Process

Type of classes	Name of the necessary basic equipment	Number of units
Laboratory work	IBM PC	8
Lectures	Multimedia projector	1
Practicals	IBM PC	8

8. Fund of the Course Evaluating Tools

Described in a separate document