Ministry of Education and Science of Ukraine
National Aerospace University
"Kharkiv Aviation Institute"

Department of Aircraft Control Systems (Dep. 301)

APPROVED:
Guarantee of the educational program
_____ A.Kulik

"27" 08 2021

WORK PROGRAM OF THE COMPULSORY DISCIPLINE

FUNDAMENTALS OF NAVIGATION

Field of Study: 17 – Electronics and Telecommunication

Program Subject Area: 173 – Avionics

Educational Program: Systems of Autonomous Navigation and Adaptive Control of Aircrafts

Level of Qualification: 1st (bachelor degree)

Kharkiv 2021

The developed study program of compulsory discipline «Processes Control in Condition of Uncertainty» is for English-speaking students of training direction 173 – Avionics

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Developer: K.Yu. Dergachov, Associate professor of the department 301, Candidate of science (Engineering)

(sign)

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(sign)

The program has been examined at the meeting of dep. 301 «Aircraft Control Systems».

Record of proceeding: № 1 from " 27 " August 2021

Head of the department
Associate professor, PhD (Engineering) K.Yu. Dergachov

(sign)

1. Course description

<table>
<tr><td colspan="2" rowspan="2">Indices</td><td rowspan="2">Field of study, Program subject area, educational program</td><td>Course specification</td></tr>
<tr><td>Full-time study</td></tr>
<tr><td colspan="2">ECTS credits – 8</td><td rowspan="3">Branch of Education:
17 – Electronics and Telecommunication</td><td>Professional training subject</td></tr>
<tr><td colspan="2">Modules –3</td><td rowspan="2">Calendar year</td></tr>
<tr><td colspan="2">Semantic modules – 8</td></tr>
<tr><td colspan="2" rowspan="3">Individual Assignment
Course Work</td><td rowspan="3">Program subject area:
173 – Avionics</td><td>2021-2022</td></tr>
<tr><td>Semesters</td></tr>
<tr><td>5</td></tr>
<tr><td colspan="2">Total hours – 240</td><td rowspan="4">Educational Program:
Systems of Autonomous Navigation and Adaptive Control of Aircrafts</td><td>Lectures [1)]</td></tr>
<tr><td colspan="2">Academic hours per day for full-time study</td><td>24</td></tr>
<tr><td colspan="2" rowspan="2">Semester 6</td><td>Laboratory classes [1)]</td></tr>
<tr><td>16</td></tr>
<tr><td>contact (in class)
4.5 hrs.</td><td>self-study
10.5 hrs.</td><td></td><td>Tutorial classes [1)]
32</td></tr>
<tr><td colspan="2" rowspan="4"></td><td rowspan="4">Level of qualification:
1st (bachelor degree)</td><td>Self-study work</td></tr>
<tr><td>168 hrs.</td></tr>
<tr><td>Assessment form</td></tr>
<tr><td>Exam, Deferential pass</td></tr>
</table>

[1)] depending on timetable, classroom studies can decrease or enlarge by one hour in a week

Note: ratio of classroom working and unaided (self-study) work makes:

72/184 (under full-time education).

2. Purpose and objectives of academic discipline

Learning Aims – studying methods and systems that allow you to determine the location of moving objects and determine rational traffic routes.

Training objectives – the study of navigation concepts and terms, theories, methods, and algorithms that solve the practical tasks of determining the location and determine the rational directions of the movement.

Learning Outcomes

On successful completion of the subject, students **should know**:

- basic coordinate systems and algorithms for converting coordinate systems;
- methods of determining the location of moving objects;
- methods for determining rational traffic routes;
- types and features of the construction and operation of modern and classic navigation systems.

should be able to:

- define their own coordinates in different coordinate systems and perform their transformation;
- determine the routes of rational movement of moving objects;
- use satellite navigation tools to solve practical navigation tasks.

3. Content of the course

Module 1

Semantic Modulus 1. Mathematical foundations of navigation

Topic 1. Introduction to the discipline "Fundamentals of Navigation".

Subject of training and discipline tasks "Fundamentals of navigation". The main historical stages of development and the formation of navigation as a science.

Topic 2. Geodetic coordinates

Geonavigational information: the shape of the Earth, the motion of the Earth, the main geographic points, lines and circles of the globe, geographic latitude and longitude, directions on the earth's surface, orthodrium, loxodromic. Earth coordinate systems: geographic, orthodrium, rectangular, polar and their relationship.

Topic 3. Methods of transformation coordinates

Principles of the transformation of geodetic coordinates in various geodetic coordinative systems. Software for converting coordinates from one system to another.

Semantic Modulus 2. Basics of cartography

Topic 4. Basics of cartography

Cartography. Map. Plan. Scale map. Classification of cards, which are applied in air navigation. Conditional signs on the map. Definition of marsrut flights on aeronautical maps. Orthodromy and Loxodromic. Orthodynamic course angle. Loxodromic way angle.

Topic 5. Basics of geoinformation systems

Geographic information systems (GIS). Basic types of geographic data. The essence objects and attributes of geographic information systems. The concept of vector geographic information systems. The concept of raster geographic information systems. Electronic maps. Large-scale geographic information systems. Spatio-time geoiformation systems. Symbols on electronic maps.

Module 2.

Semantic Modulus 3. Physical basics of navigation

Topic 6. Physical basics of navigation

The laws of the motion of the heavenly bodies. Magnetism, the rotation of celestial bodies. Laws of gravity. Kepler's laws for describing the orbital motion of navigation satellites.

Semantic Modulus 4. Navigation systems

Topic 7. Navigation systems

Airborne and terrestrial air navigation systems. General characteristics of technical means of air navigation. Monitoring of the technical state of the CNS / ATM system. Efficiency of aeronautical systems, as well as methods of increasing it. Invalid air navigation systems. Ground systems interpreted by the pilot. Use, accuracy and limitations of terrestrial systems. Classification of radio navigation means. Satellite radio navigation systems. Radios system of close navigation. Radio beacon landing systems. Systems collision PC. Radio navigation technique. Modern data transfer technologies. The system of extinguishing Observation system. Navigational characteristics, which are being used. Information processing in radio navigation devices.

Module 3.

Semantic Modulus 5. Protocols for satellite information exchange

Topic 8. Protocols for satellite information exchange

The concept of the exchange protocol. Protocol NMEA 0163, Binary, Novatell. Formation of data of navigation satellites and data executed by the consumer receiver in standardized formats. Data structure of various satellite navigation systems.

Semantic Modulus 6. Satellite navigation systems

Topic 9. Principles of construction of satellite navigation systems

SNS in accordance with the basic normative functional parameters. Develop SNS configurations in accordance with the stated requirements. Modeling (calculation) of data on accuracy, integrity, continuity of service and operational readiness. The scheme of satellite navigation receivers of consumer-cha, the principles of the operation of the main functional blocks and units of a typical traveler's navigational receiver, the scheme of construction and the principle of operation of the units of detection, search and tracking of the signal of the navigational satellite. Symbolic signal information of global navigation satellite systems. Methods of code and frequency division of channels using different systems of satellite navigation.

Module 4

Semantic Modulus 7. Systems for automatically determining the location of moving objects

Topic 10. Systems for automatically determining the location of moving objects.

Principles of construction monitoring systems. Application of monitoring data to assess the accuracy, integrity, continuity of service and ex-operational availability of satellite navigation systems.

Topic 11. Research systems for the automatic determination of the location for moving objects.

Designing systems for automatic detection of moving objects. Investigation separate elements of the system during the course work.

Semantic Modulus 8. Determining user's location using iterative method

Topic 12. Theoretical part.

The theoretical part includes an analytical presentation of the material on a given topic.

Topic 13. Practical part.

Practical part includes recording navigation and observation messages of RINEX format, receiving an information about satellites' coordinates and

pseudoranges, calculating users position, accuracy of calculations and DOPs, conclusions, build the location of satellites relative to the observer in Cartesian and polar coordinate system.

Receive the navigation and observation messages of RINEX format using the procedure of Laboratory work № 1 of last semester.

Using Novatel software, perform a measurement of navigation satellite movement. Add measurements to table. You need to registered data every 5 minutes. You have to register 10 measurements.

Add to pseudo-ranges that are used to solve navigation tasks equal increments (using w - Coefficient of the artificial errors in the pseudorange). Execute the file. Analyze and explain the results. Record the data in the report.

4. Course structure

Semantic modules and topics	Hours									
	full-time					part-time				
	total	among them								
		lec	pr	lab	indep					
1	2	3	4	5	6	7	8	9	10	11
Module 1										
Semantic Modulus 1 – Fundamental devices of electronic engineering										
Topic 1. Introduction to the discipline "Fundamentals of Navigation".	12	2	-	-	10	–	–	–	–	–
Topic 2. Geodetic coordinates.	16	2	-	4	10	–	–	–	–	–
Topic 3. Methods of transformation coordinates.	16	2	4	-	10	–	–	–	–	–
Total for semantic modulus 1	44	6	4	4	30	–	–	–	–	–
Semantic Modulus 2 – Fundamental analog electronic circuits										
Topic 4. Basics of cartography	18	2	4	-	12	–	–	–	–	–
Topic 5. Basics of geoinformation systems	16	2	-	4	10	–	–	–	–	–

Total for semantic modulus 2	34	4	4	4	22	–	–	–	–	–
Module 2										
Semantic Modulus 3 – Physical basics of navigation										
Topic 6. Physical basics of navigation	18	2	–	4	12	–	–	–	–	–
Total for semantic modulus 3	18	2	–	4	12	–	–	–	–	–
Semantic Modulus 4 – Navigation systems										
Topic 7. Navigation systems	18	2	4	-	12	–	–	–	–	–
Total for semantic modulus 4	18	2	4	-	12	–	–	–	–	–
Module 3										
Semantic modules 5 - Protocols for satellite information exchange										
Topic 8. Protocols for satellite information exchange	20	2	2	2	14	-	-	-	-	-
Total for semantic modulus 5	20	2	2	2	14	–	–	–	–	–
Semantic modules 6 - Satellite navigation systems										
Topic 9. Principles of construction of satellite navigation systems	14	2	2	-	10	–	–	–	–	–
Total for semantic modulus 6	14	2	2	-	10	–	–	–	–	–
Module 4										
Semantic modules 7 - Systems for automatically determining the location of moving objects										
Topic 10. Systems for automatically determining the location of moving objects	18	4	-	2	12	–	–	–	–	–
Topic 11. Research systems for the automatic determination of the location for moving objects.	14	2	-	-	12	–	–	–	–	–
Total for semantic modulus 7	32	6	-	2	24	–	–	–	–	–
Semantic Modulus 8 – Determining user's location using iterative method										

Topic 1. Theoretical part.	28	–	6	–	22	–	–	–	–	–
Topic 2. Practical part.	32	–	10	–	22	–	–	–	–	–
Total for semantic modulus 8	60	–	16	–	44	–	–	–	–	–
Course total	240	24	32	16	168	–	–	–	–	–

5. Topics of tutorial

№ a/o	Topic name	Hours
1	Local vehicle navigation. Calculation nomenclature of maps.	4
2	Methods of Coordinate Transformation	4
3	Research parameters of motion for navigational spacecraft	4
4	Solution of navigation tasks	2
5	Studying the orbital motion of the navigational spacecraft	2
6	Theoretical part.	6
7	Practical part.	10
	Total	**32**

6. Topics of lab classes

№ a/o	Topic name	Hours
1	Study navigation methods using computer programs	4
2	Research aircraft motion parameters according to track measurements.	4
3	Research methods for determining location data on the course.	4
4	Research methods of coordinate transformation	2
5	Research Opportunities software NOVATEL	2
	Total	**16**

7. Self-study (unaided works)

№ a/o	Topic name	Hours
1	Introduction to the discipline "Fundamentals of Navigation".	10
2	Geodetic coordinates.	10
3	Methods of transformation coordinates.	10
4	Basics of cartography	12
5	Basics of geoinformation systems	10
6	Physical basics of navigation	12
7	Navigation systems	12
8	Protocols for satellite information exchange	14
9	Principles of construction of satellite navigation systems	10
10	Systems for automatically determining the location of moving objects	12

11	Research systems for the automatic determination of the location for moving objects.	12
12	Includes an analytical presentation of the material on a given topic in a volume of 10-12 pages	22
13	Recording navigation and observation messages of RINEX format, receiving an information about satellites' coordinates and pseudoranges, calculating users position, accuracy of calculations and DOPs, conclusions, build the location of satellites relative to the observer in Cartesian and polar coordinate system	22
	Total	**168**

8. Teaching methods

Lectures delivering, conducting lab classes, individual consultations (if necessary), independent work of students with tutorials issued by the department (learning the manuals). Conducting classroom lectures, individual consultations, individual students work on materials published by the Department, participation in conferences and competitions.

9. Forms of control

Current test points that score submitted lab reports and individual assignments, evaluation (grades) of semantic topics, final examination.

10. Appointment of grade points obtaining by a student (credit points)

Current tests and unaided work								Summative test (examination) due to refusing the received current points and intent taking the exam if allowed
Semantic Modulus №1	Semantic Modulus № 2	Semantic Modulus №3	Semantic Modulus №4	Semantic Modulus №5	Semantic Modulus №6	Semantic Modulus №7	Sum	
T2	T3	T4	T6	T7	T8	T9	**100**	**100**
10	**10**	**10**	**20**	**20**	**20**	**20**		

11. Assessment criteria and points distribution that students receive

11.1. Points distribution that students receive

5 semester

Components of educational work	Marks per lesson (task)	Number of lessons (tasks)	Total marks
Semantic Module 1			
Lectures work	0…1	3	0…3
Execution and protection of laboratory works	0...5	2	0...10
Execution and protection of practical works	0..5	2	0..10
Semantic Module 2			
Lectures work	0…1	2	0…2
Execution and protection of laboratory works	0...5	2	0..10
Execution and protection of practical works	0..5	2	0..10
Semantic Module 3			
Lectures work	0…1	1	0..1
Execution and protection of laboratory works	0...10	2	0..10

Execution and protection of practical works	-	-	-
Semantic Module 4			
Lectures work	0…1	1	0..1
Execution and protection of laboratory works	-	-	-
Execution and protection of practical works	0..5	2	0..10
Semantic Module 5			
Lectures work	0…1	1	0…1
Execution and protection of laboratory works	2..5	1	2..5
Execution and protection of practical works	2..5	1	2..5
Semantic Module 6			
Lectures work	0…1	1	0…1
Execution and protection of laboratory works	2...5	1	2..5
Execution and protection of practical works	2..5	1	2..5
Semantic Module 7			
Lectures work	0…1	3	0…3

Execution and protection of laboratory works	2..5	1	2..5
Execution and protection of practical works	-	-	-
Total for the semester			**60...100**

The exam ticket consists of theoretical and practical questions. Example.

Theoretical questions:

Geonavigational information: the shape of the Earth, the motion of the Earth, the main geographic points, lines and circles of the globe, geographic latitude and longitude, directions on the earth's surface, orthodrium, loxodromic. Earth coordinate systems: geographic, orthodrium, rectangular, polar and their relationship

Practical questions:

1. The concept of the exchange protocol. Protocol NMEA 0163, Binary, Novatell. Formation of data of navigation satellites and data executed by the consumer receiver in standardized formats. Data structure of various satellite navigation systems.

2. Principles of construction monitoring systems. Application of monitoring data to assess the accuracy, integrity, continuity of service and ex-operational availability of satellite navigation systems.

11.2. Qualitative evaluation criteria

Knowledge required for positive evaluation: knowledge in digital signal processing and sufficient programming skills in the MATLAB environment, which provides great opportunities for efficient signal and designing systems for automatic detection of moving objects. Investigation separate elements of the system during the course work.

Required skills for positive evaluation: Be able to use: Methods for analyzing video data (saved as a file or obtained directly from your camcorder) using Image Processing Toolbox, Computer Vision System Toolbox in Simulink, and Image Acquisition Toolbox.

11.3. Criteria for evaluating student work during the semester

1. Excellent (90 ÷ 100 points) is presented to the student:

1.1 Who knows firmly: the basic concepts and principles pertaining to the discipline of uncertainty management. Has defended all practical, laboratory and

individual tasks, completed all modular tasks with a rating of "excellent", has solid practical skills in circuit design. Freely uses the educational and scientific literature on the subject of discipline. He can logically and clearly form his answer, solve practical and laboratory tasks.

1.2 A reduction in the number of points within the assessment is possible with inaccurate wording in the answers to the additional questions posed to it.

2. Good (75 ÷ 89 points) is presented to the student:

2.1 Having sufficient knowledge of the theoretical part of the discipline. Defended all practical, laboratory and individual tasks, completed all modular tasks with a rating of "good", has practical skills in circuit design. Correctly solves practical tasks, its answers are not clear.

2.2 A reduction in the number of points within the assessment is possible if the theoretical or practical questions are not fully answered

3. Satisfactory (60 ÷ 74 points) is presented to the student:

3.1 Who has weak theoretical knowledge, has a minimum of knowledge and skills, makes mistakes in solving practical problems. Has defended all practical, laboratory and individual tasks, completed all modular tasks, has unsure practical skills in circuit design.

3.2 A reduction in the number of points within the assessment is possible due to inaccurate and incomplete answers to theoretical and practical questions.

Grading scale: national and ECTS

<table>
<tr><td rowspan="2">Total marks</td><td colspan="2">National validation grade</td></tr>
<tr><td>Exam</td><td>Pass</td></tr>
<tr><td>90 – 100</td><td>excellent</td><td rowspan="5">pass</td></tr>
<tr><td>83 – 89</td><td rowspan="2">good</td></tr>
<tr><td>75 – 82</td></tr>
<tr><td>68 – 74</td><td rowspan="2">satisfactory</td></tr>
<tr><td>60 – 67</td></tr>
<tr><td>1 – 59</td><td>unsatisfactory</td><td>no pass</td></tr>
</table>

11.4 Distribution of points received by students for completing course work

Explanatory note	Illustrative part of job	Work protection	The sum of points
to 40	to 40	to 20	100

12. Recommended reading

Basic

1. Air navigation [Text] / U.S. Department of transportation, Federal Aviation Administration, Airman Testing Branch, – Oklahoma city, 2014. – 288 p.

2. Hofmann-Wellenhof B., Lichtenegger H., Wasle E. Global Navigation Satellite Systems [Text] / Hofmann-Wellenhof B., Lichtenegger H., Wasle E.– Austria, 2008 . – 546 p.

3. Bose A., Bhat K. N., Kurian T. Fundamentals of navigation and inertial sensors[Text] / A. Bose, K. N. Bhat, T. Kurian – Delhi, 2014 . – 425 p.

4. Walper, J. Mathematical notions for navigational aircraft [Text] / J. Walper – McGraw-Hill Education, 2017 . – 358 p.

5. Trewor, T. Air navigation [Text] / T. Trewor – Publisher Ltd, 2018 . – 512 c.

6. Bore, F. Fundamentals of Radio Navigation [Text] / F. Bore – Prentice Hall, 2015. – 392 p.

Complementary reading

1. Dempsey, P. Laws of Air Navigation [Text] / P. Dempsey – Springer Science & Business Media, 2012 . – 270 p.

2. Mohinder, S. Greouol, A., Andrews, P., Barton, K., Global Navigation Satellite System, Inertial Navigation and Integration [Text] / S., Mohinder, A. Greouol, P. Andrews, K. Barton, – Inc. Published by John Wiley & Sons, Inc., 2013 . – 561 p.

13. Information resources

Department's site: k301info